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Diver going down to make sure that all cables are holding and lifting evenly

RAISING A SUNKEN COAL BARGE IN NEW YORK HARBOR. (See page 232)

The New American Merchant Marine—I

A Plan for the Ownership and Operation of the Vessels Built for the Government by the U. S. Shipping Board

By Edward N. Hurley, Chairman of the Board

THE first public address that I delivered as Chairman of the United States Shipping Board was before the National Marine League about one year ago. At that time the world war was at its lowest ebb insofar as the Allies were concerned. The Cambrai battle had been fought and lost by the British; the French had been driven back, and all the indications were that the submarine would continue sinking more ships than the world could produce, which meant that Germany's ruthless submarine warfare would succeed in the effort to starve Great Britain, and that the world itself would face the disaster of a German victory. At no time during the bitter struggle was the outlook more black for the Allies. Then it was that Mr. Lloyd George issued an appeal that came to us clanging like a bell. It was "Ships, ships and more ships"—a strident call that rang out a warning to the world that if the war was to be won we must have the ships and have them quickly.

At the time of my last address before this body, the present Shipping Board, which had been organized little more than half a year before, had by dint of unexampled effort added 81 steel and wood ship-building yards to the small nucleus we possessed at the beginning, and had expanded 18 other yards. In these new and expanded yards we were then building ships on 235 launching ways.

OUR STRENGTH IN SHIP PRODUCTION.

At the time of the signing of the armistice, we had 341 shipyards practically completed and a total of 1,284 launching ways. This is more than double the number of yards owned by all of the rest of the world combined.

On March 1, of this year, the present United States Shipping Board completed the first year and a half of its existence. During those eighteen months it has added to our mrechant marine a total of 619 wood and steel vessels aggregating 3,640,406 deadweight tons. This is a world record in construction. It needed to be. If Great Britain had gone under, the war would have been ended before we could have gotten into it. It was during those dark days that it was stated in the House of Commons that if submarine losses continued to be sustained without replacement, Great Britain would be in deadly danger within six months, and ruined in nine.

Lord Northcliffe, who knew the seriousness of the situation, and delivered a number of speeches in many States urging the great necessity for ships, was here at that time and called on me frequently to find out what progress we were making. Everyone realized that unless we could build ships faster than the submarines were sinking them the war would be lost, for we could not feed the Allies and our soldiers, nor supply them with munitions. And, gentlemen, it was not a question of what kind of ships should be built. Any kind would do—concrete, wood, steel, or anything else. And it was not a question of price. It was a question of getting the ships. What has been accomplished in this direction the world knows, and I am not going to dwell on it extensively, but I wish to say that the men I asked to join our organization, like Mr. Schwab, Mr. Rosseter, Mr. Franklin, and Mr. Piez, did great work, and the workmen in the yards accomplished wonders. We built up a hurried organization with the biggest men we could find, and there was no thought about who was going to get the credit. We knew that if we succeeded the country we were serving would get the benefit, and that was incentive enough for any man.

FACTS ABOUT THE WOODEN SHIPS.

We have heard a great deal of criticism about the wooden ships. We all know that for most of the needs of modern ocean trade wooden ships are not as good as steel ships. There is no secret about that, and during the war you did not hear many protests against the building of wooden ships. We now have 115 wooden ships in service. We originally contracted for 708 of these vessels. We have cancelled and suspended 214 contracts. We are not now equipping the hulls that are finished, with engines and boilers. We are finishing off some of them as sailing vessels and some as barges. In general, we are handling the matter along business lines, and in this connection I would like to relate an incident that occurred in England in connection with the British building wood ships.

* An address delivered before the National Marine League in New York.

Mr. Lloyd George insisted that the British should build wood ships in Canada, in Australia, and in England, and a committee of British shipping men called upon him and protested against the Government's spending of money on wood ships, making the claim that they were not as effective as steel ships, etc. After listening attentively to their protests, Mr. Lloyd George made this statement: "Gentlemen, all you say about the wood ships being inferior to steel ships is undoubtedly true, and under ordinary conditions I would be governed entirely by your judgment. But we are now at war and we cannot win the war without ships, whether they be wood, steel, or any other kind. If these ships will make but two or three trips, build them. We must have ships."

The wooden ships we have will make many trips, and as an emergency ship they have been of great service. Although they are not suited to compete with fast steel liners in the trans-Atlantic trade, they will continue to be of service in trades where they are suitable. The existing world shortage of tonnage is sufficient guaranty of this. Insofar as seaworthiness is concerned, I wish to point out that while we have sustained four total marine losses among our wooden ships, we have sustained five among our steel ships. Of these total losses, one wood ship and one steel ship foundered at sea in heavy weather, so that on the score of *seaworthiness* the honors are even. The other total losses were due to stranding or collision, accidents as likely to happen to a steel ship as to a wooden ship, and which have no bearing whatever on the question of seaworthiness. At any rate, if this war had gone on until 1920 the wood ships might have made it possible to have won the war, and then no one would have criticized the policy of building wooden ships.

As Senator Duncan U. Fletcher, Chairman of the Senate Committee on Commerce, recently told the members of the Merchant Marine Conference, it was time to build ships out of anything that could be used for ship construction, to build ships out of wood, out of concrete, out of steel, out of anything that could float—out of anything that could carry men overseas and keep them supplied with food and ammunition. It had to be done then. And it had to be done quickly. There was no time for temporizing. I will quote you a paragraph from the Senator's address. He says:

LIVES AND MONEY SAVED.

"You couldn't wait and say, 'Hold on until things stabilize themselves; hold on until we get to normal conditions. We will then save a few thousand of Uncle Sam's money.' Millions of lives and millions of money were saved by doing the very things that were done; by hurrying up this program and building ships night and day; by letting the world know we had the most stupendous building plants on earth; that we had the men, we had the money, we had the material; that we were going to carry our forces overseas, and with them their supplies; that we had two and a quarter million men over there, two million more in training here, and thirteen million registered and ready to go.

"And when Germany saw that she ran up the white flag."

I want to mention here one thing that I believe had more to do with arousing our country to the necessity of building ships than any other one thing, and that was our campaign for volunteers. While the people of the country knew of the heavy losses of tonnage from submarine sinkings, they did not understand the seriousness of the situation. Our people, not understanding, were not supporting us in the way they should. Their thoughts were on their business and their sons, who were going into the training camps and sailing for Europe.

Feeling that some step should be taken to create a spirit of enthusiasm in the hearts of the mechanics and workers, as well as the people in general, we introduced a plan whereby we were to raise an army of 250,000 patriotic workers to serve in the shipyards. We limited the time for this enrollment to ten days, and I am happy to say at the end of that time 285,000 men throughout the United States had volunteered to leave their homes and families and report for duty at the various shipyards when we notified them to do so. The effect of the enrollment of the workers and the educational campaign was that within nine months we had increased the number of employees in our shipyards from 45,000 to 380,000; had built 65 new shipyards; had the entire country back of our program, and in one day, the Fourth of July, launched 96 ships.

CREDIT DUE SHIPYARD WORKERS.

This message was conveyed to General Pershing, and there is no question but that it heartened him and every soldier and imbued them with the knowledge that the American people were back of the shipbuilding program, and that the ships would be furnished to help them carry on the work of aiding to win the war. I am sure that it also heartened all the Allies. The men deserving of the credit for this great success are the workers in the shipyards, and the enthusiastic people back of them. Every newspaper, every magazine, every moving-picture theatre, and the 4-minute men organization, consisting of 20,000 speakers, were used to impress upon the people the need for the construction of ships with the greatest possible speed.

We have part of our foreign fleet built, while we are constructing more. We shall have authorizations and appropriations to finish if Congress gives us the money we ask, which I feel confident they will. We shall have completed ocean-going ships, not lake or coastwise ships. I am only referring to ocean-going steamers adapted to foreign trade. The world war has broadened our vision so that we think nothing today of distance. We are now thinking not only nationally, but internationally, and we must think internationally if we are going to be a factor in the world's game.

PLAN OF SHIP OPERATION.

When I last addressed you, it was my privilege to outline to you the American shipbuilding program. Tonight I desire to present for your consideration an American ship-operating program. The operation of a fleet of 16,000,000 tons of ships, 70 per cent. of which is owned by the Government, is a problem that should be carefully considered from every angle, and in presenting this plan for your best thought, I feel I should say that the Government, without unnecessary delay, must take a prompt and definite step in giving legislative form to this, or some other policy which will meet with the approval of the country.

While the war was on, the recital of shipbuilding achievement found a quick and ready response from an enthusiastic public. There is less glamor and glory in the work of evolving a policy which will keep these ships under the American flag, and develop our commerce, but this work touches the life of the nation almost as closely as the emergency shipbuilding program.

Upon the development of our foreign commerce will depend in a large measure the prosperity of all the American people, the employment and happiness of labor, and the respect of the nations which compete with us. I am personally opposed to government ownership, except as a last resort. During the war, it was necessary for the government to build a merchant fleet. Private capital never could have accomplished this colossal task, involving the creation of many new shipyards, and the training of a large army of workmen.

Government ownership of this large fleet resulted automatically. If we are to return to private ownership, the transition must be made under such conditions as will completely safeguard the interest of the public. If this fleet, built at government expense, were to be used now merely for the advantage of groups of ship-operators, with sufficient capital to purchase the ships from the Government, I would unhesitatingly advocate the retention of the whole fleet by the Government.

WANT NO OVERCAPITALIZATION.

The problem is quite as complex as the railroad problem. Its solution is vital to the welfare and prosperity of the nation. Private ownership unquestionably offers an inducement to American energy and skill, but one of the phases of unrestricted private control, which caused me considerable concern, was the possibility that under such control, ships would be overcapitalized as were many of the railroads. We want the initiative and skill of American ship-operators, but we want no watered stock. We want to avoid the stagnation that sometimes comes from red tape and bureaucracy, but we want no profiteering or exploiting.

We want the new fleet used for the benefit of the people of the United States and not against their larger interest. We want it used for the development of the nation's commerce, and not merely for the development of the private fortunes of ship-operators.

No one will deny that our foreign trade, or the operation of American ships, will decline unless there is a profit for the men who invest their money. But whatever assistance the Government is willing to render, should be reciprocated by those who are benefited. Therefore the nation's shipping policy should certainly provide for such governmental representation as will guarantee a square deal to the public.

I think the whole nation is agreed that there must be no more scandals of overcapitalization in any part of American industrial or commercial life. The ships built by the nation should never be made the basis for any stock-jobbing scheme. I think the nation will see to it that they are not so used.

PROTECTION FOR SMALL OPERATOR.

If there is to be any monopoly, moreover, it must be a government monopoly. If there is to be a private initiative, the field must be kept open to the small operator, whose opportunity to compete with the large operator must be protected by the Government. The mere possession of large capital must not give the larger operator an opportunity to drive the smaller man out of business. In the plan I am ready to submit for the best thought and impartial discussion of the country, I believe you will find that the fundamental American theory of encouraging competition on fair terms is amply safeguarded.

When we recognize the precautions that must be taken to safeguard the interest of the public, there is no further need for hesitation in meeting a large problem in a large way.

It is my hope that the people of America will view the problem broadly. The men who earn their livelihood from the operation of ships naturally will feel that they are chiefly concerned. The men who build ships also have a very large interest in it. Our first thought, however, must be of the effect of any inadequate solution upon the hundred million people who composed the United States. Their interest must come first.

In my judgment, any policy which does not encourage the building and the extensive operation of ships under the American flag will not satisfy the American people. I believe that a sound policy can be put into the form of legislation and that it will then form a permanent foundation on which further improvements, as the need for them appears, can be erected.

SHIPS NOW OWNED BY GOVERNMENT.

The United States Government now owns 555 ocean-going steel cargo ships aggregating 3,385,475 deadweight tons. In addition it has under contract 1,336 similar vessels of 9,275,006 deadweight tons. If our present program be carried out, there will be under the American flag next year 16,732,700 deadweight tons of ocean-going steel cargo and passenger ships. This fleet will be the equivalent of almost half the merchant tonnage which plies the seas today under the flags of all nations combined. The Government will own about 70 per cent. of it.

The economic importance of this great fleet would be difficult to overestimate. Upon its successful operation under a sound financial and administrative plan by vigilant, courageous men who have the interest of American industry and commerce at heart, depends more than upon any other factor the future development of our overseas trades, and of the domestic industries which feed it. Therefore, while the clouds of war disperse and the conditions of the new era begin to unfold, I desire to invite your attention to a digest of the various plans which have been suggested, and to submit to you the plan which seems to me for the best interest of the whole country, for the disposition of the Government's ships, and for the development of the American merchant marine.

DIFFERENT PLANS SUGGESTED.

The plans which have been considered range between Government ownership and operation on the one hand, and unregulated private ownership and operation on the other. In general, they fall into one or more of the following classifications:

1. *Government Ownership and Operation.*—Under this plan, title to all vessels now owned by the Government would remain in the Government, and their operation would be conducted by Government employees and agents. The adoption of this plan would necessitate the permanent establishment of a Government operating force with branch offices and agencies in every port of the world. Cargoes and passengers would be booked by the Government representative, and the accounts would be cast up at the central operating offices in Washington.

2. *Government Ownership and Operation for the Benefit of the Government Through the Medium of a Private Corporation.*—This, in effect, does not differ from operation directly by the Government, except that under such a plan Government operation might be more easily administered, and some of the inertia inherent in governmental undertakings might be overcome.

3. *Government Ownership and Private Operation for Government Account.*—Under this plan the Government would retain its ownership, but private companies would be employed as agents on a commission basis to operate the vessels for Government account.

4. *Government Ownership and Private Operation for Private Account.*—This would mean the retention of Government ownership under a leasing system by which the vessels would be leased or chartered to private steamship companies. After paying the charter hire to the Government, the operator would keep the rest of the earnings.

5. *Ownership by a Single Private Corporation.*—Under this plan title to all vessels would be placed in one large private corporation, the stock of which would be sold to the public, the Government, if it chose, guaranteeing a fixed return on the stock. This would entail the centralization of the ownership and operation of the ships now owned by the Government in one large unit. If the Government guaranteed a fixed return on the stock, the result would be that the machinery for the ownership and operation of the fleet would be practically identical with that suggested in plan No. "2," but with the modification that the Government would carry any losses which might be incurred without receiving the benefit of any profits which might be earned.

6. *Private Ownership and Operation.*—Lastly, the vesels can be sold to private companies, to be operated by them entirely for their own account, the Government thus relinquishing all interest and control.

ARGUMENTS IN FAVOR OF GOVERNMENT OWNERSHIP.

The argument in favor of Government ownership and operation is that this great fleet, which has been created with taxpayers' money, should be used for national purposes; that the ships have not been built to earn profits as ships, but to become the servants of the nation which built them. It is urged that they should be used to develop the commerce of the nation as a whole, and that they should, if necessary, be placed in trade routes which may temporarily prove unprofitable, but ultimately become of great value to the nation as an instrument through which its foreign commerce can be increased.

Private companies would not be disposed to serve the national interest in this way. The life of a ship is comparatively short. Its owner must make it pay today. He cannot be expected to take a loss today in order to build up a commerce which will become a source of profit only after the ship now engaged in that commerce has been scrapped. The great need of this country is that new trade routes should be established, and it is urged that Government ownership and operation should be retained as a guaranty that all ships will serve the nation as a whole and not a limited class of private shipowners.

A further argument in favor of public ownership and operation is that in case of a national emergency such as has just been experienced, the Government would be in a position immediately to convert its merchant fleet into a military weapon.

ARGUMENTS IN FAVOR OF PRIVATE OWNERSHIP.

The chief argument in favor of private ownership and operation is that a successful merchant marine depends not so much on ships, or money, or Government aid, as it does on the existence of a large class of alert, resourceful and energetic men engaged in the shipping business. Mere mechanical efficiency of ship and shore plant, added to sound financial backing, is not enough. The man who enters the shipping business enters a battle against the wits of the world. He must have a genius for shipping. Fortunately the men now engaged in the shipping business in the United States are of that character. But there are not enough of them. We need many more. And it is clear that the number of such men can be greatly increased only under conditions of private initiative. The shipping business is a business of infinite detail and infinite technique; yet it calls for great courage and wide-ranging imagination. The formalities necessarily surrounding Government operations are not suited to the successful conduct of a shipping venture, requiring quick decision, sudden reversals of policy, and the assuming of great hazards. The successful shipping man in an emergency consults no book of rules. He consults only his wits. So, it is contended, that only under private operation may we expect a further increase in the number of small, independent, skillful ship-operators which we shall need more and more as the American merchant marine expands its activity upon the seas.

Furthermore, the establishment of a merchant marine under the American flag must take into account the difficulty of securing return cargoes. If ships must be brought back in ballast, the business cannot be profitable. In order that a round trip may be made without a considerable portion of it being in ballast, it may be necessary to engage in a triangular or polygon voyage. In order profitably to carry a cargo from New York to Australia, it may be necessary also to carry a cargo from Australia to Japan; thence a cargo to the Cape Verde Islands, with the short return trip in ballast to New York. Such operations require a degree of special negotiation and freedom from control to which Government operations are entirely unsuited. They cannot be standardized. No rule can be laid down which a Government employee could follow, for the conditions are constantly shifting, and in this tramp business the competition of the whole world must be met, facility with facility, and rate with rate.

RECOMMENDATIONS.

A careful consideration of these arguments has led me to the conclusion that the ships should be sold to and operated by American citizens under no restrictions other than the terms of the bill of sale and the fixation of maximum freight rates, either as provided in Section 18 of the Act approved September 7, 1916, or as may be agreed by the Government and the operator in specific instances.

The ships should be sold at a price which fairly reflects the current world market for similar tonnage.

Twenty-five per cent. of the purchase price of each ship should be paid down, the remainder falling due and payable in graded annual installments over a period not exceeding ten years. The Government should take and hold a mortgage for the unpaid balance, charging interest thereon at the customary commercial rate of five per cent. One-fifth of this interest, representing the difference between the customary Government interst of four per cent. and the customary commercial rate, should be paid into a Merchant Marine Development Fund to be described hereafter.

The purchaser should be required to agree to insure and keep insured with an American Marine Insurance Company, his equity in the vessel, and because the American marine insurance market has not at present sufficient resources to underwrite all the vessels the Government has to sell, the Government should carry in its own fund, as at present, but for purchaser's account, hull and machinery insurance covering that part of the vessel for which payment has not been made. Our experience in operation shows that the Government can carry this insurance for at least one per cent. less than the open market rate. However, it is proposed that the open market rate be charged, and that the difference be paid into the Merchant Marine Development Fund.

It is understood that no transfer of a vessel to foreign registry should be permitted without express permission of the Government.

Each purchaser who wishes to operate in the foreign trade should be obliged to incorporate under Federal charter, the necessary legislation for which should be passed by Congress without delay. Such a charter should provide that no stock shall be issued in excess of the money value actually paid in on vessel property, and that no stock can be issued or transferred to an alien.

It should also provide that one member of the Board of Directors for each company shall be named by the Government. This director should draw no salary, either from the steamship corporation or from the Government. He should receive only the customary director's fee for each meeting he attends.

The same legislation should provide for periodical meetings of these Government-named directors, in the City of Washington, where they will constitute an official body which will confer with and advise the Shipping Board, or other designated Government agency, upon problems arising in, or questions affecting the welfare of, the American Merchant Marine, including the administration of the Merchant Marine Development Fund.

[TO BE CONTINUED.]

The Bulk of Commodities

MOST of us have been at one time or another embarrassed by inability to find in any book of reference a statement of the weight per unit of volume for some commodity. The want indicated has just been filled by the Bureau of Standards, which has issued a little book entitled "Tables of Unit Displacement of Commodities." The compilation seems to be a very exhaustive one indeed.

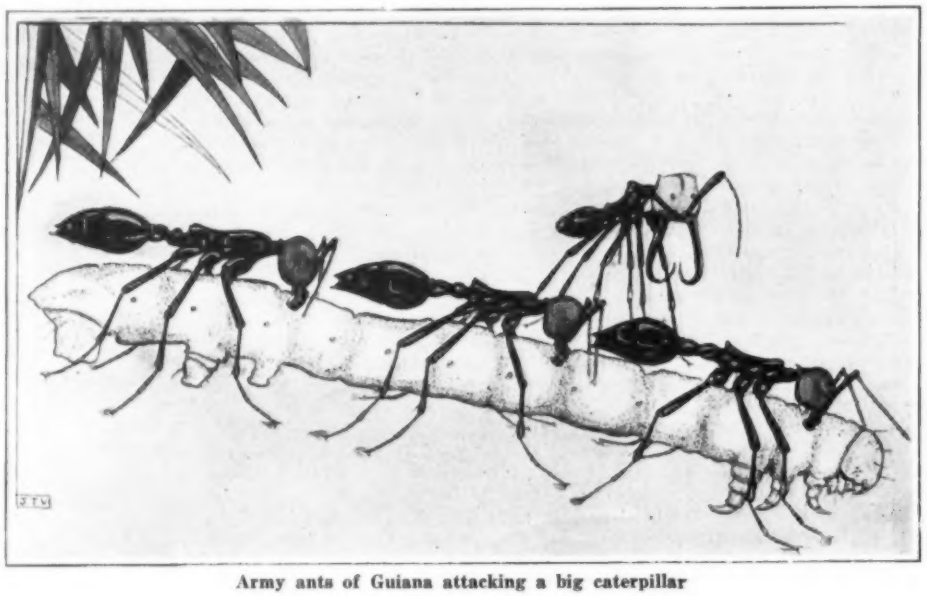
Insect Tyrants*

The Army Ant and Some of His Methods

By William Beebe

I stood on the brim of a pit dug in an ancient sand dune in the heart of the Guiana wilderness. A horde of those Huns of the jungle, army ants, had made their drive directly across the glade, and scores of fleeing insects and other creatures had fallen headlong into this deep pit. From my man's height it was a dreadful encounter, but crowding near the edge it became even more terrible; and when I flattened myself on the sand and began to distinguish individuals, and perceive details from an ant's point of view, I realized the full horror and irresistibility of an assault by these ants.

I perceived a large toad squatted on a small shelf of sand in the pit, close to the edge of a crowded column of ants. He was a rough old chap, covered with warts and corrugations, and pigmented in dark grey, with mottlings of chocolate and dull red and occasional glints of gold. He was crouched flat, with all his fingers and toes tucked in beneath him. His head was drawn in, his eyes closed, and all his exposed surface was sticky with his acid perspiration—the sweat of fear. He knew his danger — of that there was no doubt—and he was apparently aware of the fact that he could not escape. Resignedly he had settled on the very line of traffic of the deadly foe, after intrenching himself and summoning to his aid all the defenses with which nature had endowed him.



Army ants of Guiana attacking a big caterpillar

And he was winning out! He was the first vertebrate I have ever known to withstand the army ants. For a few minutes he would be ignored and his sides would vibrate as he breathed with feverish rapidity. Then two or three ants would run toward him, play upon him with their antennae, and examine him suspiciously. During this time he was immovable. Even when a soldier sank his mandibles deep into the roughened skin and wrenched viciously, the toad never moved. He might have been a parti-colored pebble embedded in its matrix of sand. Once when three bit him simultaneously, he winced, and the whitish, acrid juice oozed from his pores. Usually the ants were content with merely examining him. I left him when I saw that he was in no immediate danger.

For the dozens of grasshoppers, crickets, roaches, beetles, spiders, ants, and harvest men, there was no escape. One daddy-long-legs did a pitiful dance of death. Supported on his eight long legs, he stood high out of reach of his assailants. He was balanced so exactly that the instant a feeling antenna touched a leg, he would lift it out of reach. Even when two or three were simultaneously threatened, he raised them, and at one time he stood perfectly balanced on four legs, the other four waving in mid air. But his *kismet* came with a concerted rush of half a dozen ants, which overbore him, and in a fraction of time his body, with two long legs trailing behind, was straddled by a small worker and borne rapidly away.

I now flattened myself on an antless area at the edge of the pit and studied the field of battle. In another half-hour the massacre was almost over. Five double, or often quadruple, columns were formed up the sandy cliffs, and the terrific labor of carrying out the dead victims began. The pit was five feet deep, with perfectly straight sides, which at the rim had been gutted by the rain, so that they actually overhung. Yet the ants which had half climbed, half tumbled their way to the bottom in the wake of their victims, now settled themselves to solving the problem of surmounting these cliffs of loose, crumbling grains, dragging loads which, in most cases, were much heavier than themselves. Imagine a gang of men set to carrying bundles of one to two hundred pounds up perpendicular cliffs twelve hundred feet in height, and the task of the army ants is made more vivid. So swiftly did they work and so constantly shift their formations and methods of meeting and surmounting difficulties, that I felt as I used to feel when looking at a three-ring circus. I could perceive and record only a small part of the ingenious devices and the mutual assistance and sharing of the complicated conditions which arose at every step.

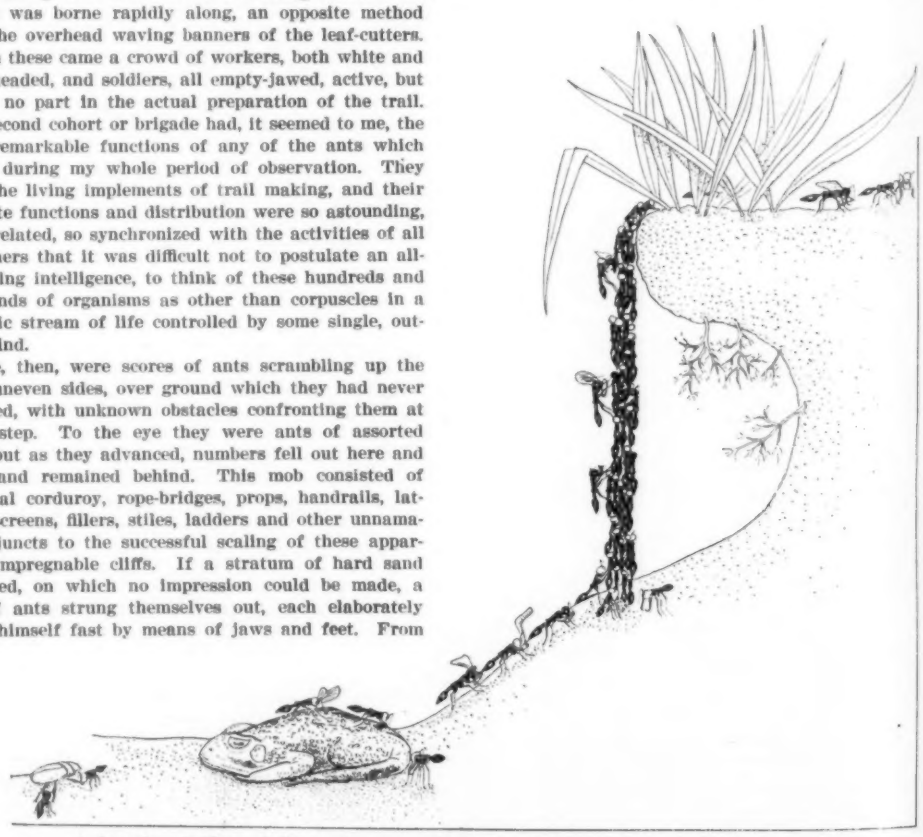
When two traffic columns reached the summit, three others were forging rapidly ahead. All used a similar method of advance. A group of mixed castes led the way, acting as scouts, sappers and miners. They searched out every slope, every helpful step or shelf of sand. They took advantage of every hurdle of white grass-roots as a welcome grip with which to bind the shifting sand-grains. Now and then they had to cross a bare, barren slope with no natural advantages. Behind them pressed a motley throng, some still obsessed with the sapper instinct, widening the trail, tumbling down loose, dangerous grains. Some bore the first fruits of victory, small ants and roaches which had been the first to succumb. These were carried by one, or at most by two ants, usually with the prey held in the jaws close beneath the body, the legs or hinder-part trailing behind. In this straddling fashion the burden was borne rapidly along, an opposite method from the overhead waving banners of the leaf-cutters.

With these came a crowd of workers, both white and black-headed, and soldiers, all empty-jawed, active, but taking no part in the actual preparation of the trail. This second cohort or brigade had, it seemed to me, the most remarkable functions of any of the ants which I saw during my whole period of observation. They were the living implements of trail making, and their ultimate functions and distribution were so astounding, so correlated, so synchronized with the activities of all the others that it was difficult not to postulate an all-pervading intelligence, to think of these hundreds and thousands of organisms as other than corpuscles in a dynamic stream of life controlled by some single, outside mind.

Here, then, were scores of ants scrambling up the steep uneven sides, over ground which they had never explored, with unknown obstacles confronting them at every step. To the eye they were ants of assorted sizes, but as they advanced, numbers fell out here and there and remained behind. This mob consisted of potential corduroy, rope-bridges, props, handrails, lattices, screens, fillers, stiles, ladders and other unnamable adjuncts to the successful scaling of these apparently impregnable cliffs. If a stratum of hard sand appeared, on which no impression could be made, a line of ants strung themselves out, each elaborately fixing himself fast by means of jaws and feet. From that moment his feverish activity left him; he became a fixture, a single unit of a swaying bridge over a chasm; a beam, an inorganic plank, over which his fellows tramped by hundreds, some empty, some heavily laden. If a sudden ascent had to be made, one ant joined himself to others to form a hanging ladder, up which the columns climbed, partly braced against the sandy wall.

At uncertain, unguarded turns a huge soldier would take up his station, with as many functions and duties as a member of the Broadway traffic squad. Stray, wandering ants would be set right by a single twiddle of antennae; an over-burdened brother would be given a helping jaw and assisted for some distance to the end of his beat. I was especially interested in seeing, again and again, this willingness to help bear the burdens. It showed the remains of an instinct, inhibited by over-development, by ultra-specialization of fighting paraphernalia, still active when opportunity gave it play. At the first hint, by sound or smell, of danger the big soldier whirled outward and, rearing high on his legs, brandished his mighty blades in mid-air. Here was an ideal pacifist, who could turn his sword into a ploughshare at will, and yet keep the former unsheathed for instant use.

When I watched more closely, I detected more delicate gradations of mutual aid. At the same level in two columns of ascent, the same stratum of hard sand was encountered. To one column the sand presented a rough surface which gave a good foothold. Here the single line of ants which was ranged along the lower edge of the trail, in lieu of hand-rail, all faced downward, so that the ants passing above them walked partly on the abdomens and partly on the hind-legs of their fellows. In the second column, the surface of the sand was smooth, and here



A hanging bridge of live ants over which the victims of the sand-pit are carried across the gap made by an overhanging edge

*From the Zoological Society Bulletin.

the burdened ants found great difficulty in obtaining a foothold. In this instance the supporting gang of ants faced upward, keeping their place solely by their six, sturdy legs. This left head and jaws free, and in almost every case they helped the passage of the booty by a system of passing from jaw to jaw, like a line of people handing buckets at a fire. The rightful carriers gave up their load temporarily and devoted their attention to their own precarious footing.

I learned as much from the failures of this particular formation as from its successes. Once a great segment of wood-roach was too much for the gallant line clinging to the sides of the pit, and the whole load broke loose and rolled to the bottom. Of the hand-rail squad only two ants remained. Yet in four minutes another line was formed of fresh ants—ants who had never been to the spot before—and again traffic was uninterrupted. I saw one ant deliberately drop his burden, letting it bounce and roll far down to the bottom of the pit, and instantly take his place in the line of living guard-rails. The former constituents of the line had clung to the roach segment through all its wild descent, and until it came to rest at the bottom. Without a moment's pause they all attacked it as if they thought it had come to life, then seized it and began tugging it upward. In a fraction of time, without signal or suggestion or order, the handrails had become porters. The huge piece of provender had rolled close to an ascending column on the opposite side of the pit, and up this new trail the bearers started, pulling and pushing in unison, as if they had been droghers and nothing else throughout the whole of their ant-existence.

One climax of mutual assistance occurred near the rim of the pit on a level with my eyes, where one column passed over a surface which had been undermined by heavy rain, and which actually overhung. I watched the overcoming of this obstacle. All the ants which attempted to make their way up at this point lost their footing and rolled headlong to the bottom. By superformicine exertions a single small worker at last won a path to the rim at the top. Around the edge of the pit innumerable ants were constantly running, trying, on their part, to find a way down. The single ant communicated at once with all which came past, and without hesitation a mass of the insects formed at this spot and began to work downward. This could be done only by clinging one to the other; but more and more clambered down this living ladder, until it swayed three inches in length, far out over the vastness of the pit. I had never lost sight of the small worker, who had turned on his tracks and was now near the bottom of the ladder, reaching wildly out for some support—ant, grass or sand. I was astonished to see that, as the length and consequent weight of the dangling chain increased, the base support was correspondingly strengthened. Ant after ant settled itself firmly on the sand at the top, until a mat of insects had been formed, spread out like animate guy ropes.

At last the ultimate ant in the rope touched the upraised jaws of a soldier far below. The contact acted like an electric shock. The farthest ant in the guy-rope gang quivered with emotion, a crowd of ants climbed down and another up, and bits of insect and spider prey began to appear from the depths of the pit, over the living carpet suspended from the brim. For an inch the droghers climbed over the bodies braced against the cliff. Then, where the surface became smooth, the dangling chain came into use. Before the rim of the pit was reached, the chain had become a veritable hollow tube of ants, all with heads inward, and through this organic shaft passed the host from the ascending column. But it was far more than any mechanically built tube. When an extra large piece of loot came up, the tube voluntarily enlarged, the swelling passing along until the booty and its bearers emerged at the top.

Within five minutes after this last column was completed, there passed over it, out of the pit, a daddy-long-legs with legs trailing, perhaps the same one which I had seen in the tragic little dance of death. There followed two silver-gray ants, a wood-roach in two installments, part of a small frog, three roaches and two beetles. These latter gave a great deal of trouble and tumbled down the cliff again and again.

When the tropical night began to close down, the last of the columns were making their way out, systematically from the bottom up, each ant following in turn. The moment the last bit of prey passed up the column, by some wonderfully delicate and subtle sense, every ant knew of it, and the corduroy rose, the hand-rails unjointed themselves, the ropes unspliced, the embankments dislodged of their own volition, and stepping-stones took to themselves legs. After hours of total inactivity, these sentient paraphernalia of the *ria formica* became, once more, beings surcharged with ceaseless movement, alert and ready to become a useful cog in the next movement of this myriad-minded machine. I jumped down into the pit. The great gold-spotted toad stretched and scratched himself, looked at me and trembled his throat. I was not an army ant.

I looked out and saw the last of the mighty army disappearing into the undergrowth. I listened and heard no chirp of cricket, no voice of any insect in the glade. Silence brooded, significant of wholesale death. Only at my feet two ants still moved, a small worker and a great white-headed soldier. Both had been badly disabled in the struggles in the pit, and now vainly sought to surmount even the first step of the lofty cliff. They had been ruthlessly deserted. The rearing of new hosts was too easy a matter for nature to have evolved anything like stretchers or a Red Cross service among these social beings. The impotence of these two, struggling in the dusk, only emphasized the terrible vitality of their distant fellows. As the last twilight of day dimmed, I saw the twain still bravely striving, and now the toad was watching them intently.

The Louse that Annoys Armies Abroad and People at Home

WHEN entomologists concluded that there are about 200,000 species of insects in the world, they forgot all about the inconspicuous, pestiferous lice. It is now believed that every species of plant, mammal, reptile, bird, fish and all other types of beings, has a separate species of louse peculiar to it while some have several species.

The body louse or "cootie," magnified over 100 diameters

Man, for instance, has three known species of lice all to himself. The most insistant and pestiferous species that attacks man wherever men exist, is pictured above, although Californians will deny it and tell you their little red louse is worse, which many travellers admit who have slept in San Francisco.

The body louse pictured above, bears the name in science of *Pediculus corporis*, enlarged 100 times. He lives in human hair and in the seams of clothing. We owe this wonderful picture of him to Ignaz Matauch, who before his recent demise, worked out the model of him at the American Museum, New York, with wonderful patience and many difficulties. He did so because this species is a carrier of typhus, which our government has stamped out all over the world, since the war began, by methods invented by our own Surgeon General, Wm. C. Gorgas. The louse itself, however, is not stamped out and has become the most formidable trench pest.

Lice are defined as degraded insects of the parasitic, hemipterous class. They are parasitic because they live upon another animal or plant, called the host. The host, of course, is involuntary, since they not only do not pay board but if disturbed in any way, return a vicious bite. Small as is the biting apparatus, a still more microscopic disease germ exists within them which they insert very deftly when they bite. The human, therefore, submits to a liberal application of kerosene oil to kill both louse and the germ he deposited. The fine tooth comb readily dislodges them from the hair of the head, but a powerful antiseptic must also be administered to kill the germ remaining under the skin. You should remember these things when your domestic animals are suffering from lice.

Lice have no wings. They have a sucking apparatus which they protrude and fix in the skin, then attach it firmly with little hooks. They have three pairs of legs, each foot with a hook for crawling and grappling. Their form is like that of an ellipse. The most of body consists of abdomen, or stomach. Their skin is so tough that when crushed it can be heard to crack. The louse is oviparous, or egg laying, and is very prolific in progeny. The eggs, called mits, are glued to the human hairs so firmly that they will stay at home and hatch all right.

The Vegetable Oil Industry of Japan

THE process of crushing seeds for oil has been in use in Japan for centuries, but it is only in recent years that the production of vegetable oils has been sufficiently large to allow of a big export trade. The real prosperity of the seed crushing industry may be said to have only commenced during the war, when the world shortage of oils raised prices. Kobe is the centre of the industry and is admirably situated as regards shipping facilities and labor supplies. While there has been a lack of tonnage all over the world, the Japanese have maintained their steamship lines to practically all the Far East ports, and Kobe has been supplied with copra from Singapore and Java, soya beans from Dairen and Vladivostok, peanuts from Tsingtao, cotton seed from Tientsin and Shanghai, rape seed from Hankow and India, and castor beans from China and India. The resulting oils have also been shipped direct to all parts of the world. The output of oils from the Kobe district is now about 5,700 tons per month divided approximately as follows: Soya 2,100 tons, coconut 1,700, rape seed 1,400, cotton seed 500, but the proportions vary with the quantities of raw materials available. The variety of raw materials is a great advantage as the mills can be turned from one product to another, generally with little alteration, to meet special demands or to fit in with the seasons of the various plants, and are thus kept continuously at work. The mills vary in size from a productive capacity of 10,000 to 360,000 gallons per month, they are all situated on the coast and all except one use the pressure system, the one exception uses the benzine extraction method. The pressure processes are very similar to those used in America. In the round type hydraulic press the amount of oil extracted at each crushing is generally small, and as many as 3 or 4 operations are necessary with copra and peanuts. The flat bed rectangular presses give a higher yield of oil per crushing but the oil needs more refining. One plant is using the latest type of rotary screw expeller mill with great success. The benzine extraction process is at present suffering from the high cost of spirit. The Japanese mills clarify the oils by filtration, but do not remove the free fatty acids. The war has created an enormous demand for castor oil as a lubricant for aeroplane engines and the production has been increased to the limits of the available supply of castor beans. Perilla oil obtained from the seed of an Asiatic mint (*Perilla ocymoides*) is made in considerable quantity; it is a drying oil used largely in Japan as a substitute for linseed oil. This product should become better known.

The oils are generally shipped from Kobe in second-hand tins which have previously been used for kerosene or petrol. This usually entails a leakage loss of about 5 per cent., but the use of more efficient and costly packages such as barrels and drums is prohibited by the high freights for returned empties, whereas the old petroleum tins are not returnable. Attempts to use tank steamers have so far failed owing to the want of large storage tanks and pumping machinery.

The general outlook of the industry is good although it is thought in some quarters that the apex of prosperity has been reached. One very important factor is the sale of the pressed cake, and, generally, Japanese mills have been able to dispose of their output locally, but occasionally mills have had to close down owing to the low price of cake. The importance of oil cake prices is shown by the fact that at the June prices of this year, 70 per cent. of the proceeds realized from soya beans came from the cake and only 30 per cent. from the sale of the oil.

Ready for Overseas Flight

THE British dirigible, R-34, launched in March, is expected to make the transatlantic flight in May. She is 700 feet long, 80 feet diameter, 95 feet high with power equipment, and has a gas capacity of 2,000,000 cubic ft.

The Marine Diesel Oil Engine*

A Discussion of Certain of the Problems Which Its Use Involves

By John W. Anderson[1]

THE method of reversing used on the two-cycle engines is based on the fact that, in these engines, the spray and scavenger valves can be set right for running in the reverse direction by shifting the cams through a common angle. One camshaft running along the tops of the working cylinders operates all the valves; there is one cam for each spray and scavenger valve and the camshaft is shifted for reversing through an angle of 30 deg. The camshaft is shifted automatically by a slip coupling having a 30-deg. angle between the jaws, so that when the engine starts in the reverse direction, the crankshaft revolves 30 deg. before the camshaft starts, that is, when the timing becomes right for the new direction of rotation. The air starting valves are operated by two separate cams, one for ahead and one for astern, and the direction of rotation of the engine is determined by bringing into action the proper cam which in turn times the starting valve.

This automatic reversing mechanism fails to work satisfactorily when the engine is operated at low speeds, because then the engine does not turn exactly uniformly, and since the slip clutch is of the friction type, with jaws to limit the extreme travel to an angle of 30 deg., and since the camshaft and its parts have inertia of their own, this slip clutch fails to hold the camshaft in exact relation to the crankshaft. This upsets the timing of the valves, which in the case of the spray valve is important.

In the 1,000-hp. engine installed in the single-screw submarine tender *Fulton* the shifting of the camshaft was made definite and positive by substituting, in place of the slip clutch, a sliding sleeve operated by a pneumatic cylinder under the control of the handling gear. The vertical shaft, which drives the camshaft from the crankshaft, is cut and the sliding sleeve connects the two parts; it slides on one of them on straight keys parallel to the longitudinal axis of the shaft, and on the other on spiral grooves, so that when the sleeve is moved along the axis of the vertical shaft the camshaft is twisted relatively to the crankshaft through the same angle of shifting used in the original design, namely, 30 deg.

To make the action still more positive, there is an automatic locking device on the pneumatic cylinder. It consists of a bar with two holes, connected to the lever operating the sleeve; corresponding to these holes there are two locking pins, one for each end of the pneumatic cylinder. The parts are so arranged that when the sleeve is in either extreme position, one of the locking pins fits into the proper hole in the locking bar and the parts are held securely in place.

When it is desired to reverse the engine, air is admitted by the handling gear to a piston on the locking pin holding the bar. This air pressure pulls the locking pin out, and when the pin is clear of the bar a port is uncovered leading to the pneumatic cylinder. The air pressure acting on the piston in the cylinder moves it to the other extreme position, setting the camshaft right for running in the opposite direction, and just as it reaches the extreme position it uncovers a port in the cylinder, admitting the air to the air starting valves on the working cylinders. Of course it is understood that when this gear reaches its new extreme position, the locking pin at that end of the cylinder registers with the hole in the bar and again locks the mechanism. The action is very simple and thoroughly foolproof and positive. This engine has been in service for some time now, and the reversing gear has amply lived up to expectations.

A similar method of reversing is used on the four-cycle engines, but unfortunately in this case it is necessary to have a separate camshaft for each kind of valve because of the different angles through which it is necessary to shift the cams in order to bring the timing right for the new direction of running. The engines are fitted with three camshafts, one for the spray valves, one for the inlet valves, and one for the exhaust valves. The air starting valves are operated by a single cam which is shifted by a separate mechanism to bring its timing right. The operation is pneumatic and the valves are controlled by plungers arranged radially around the single cam in accordance with the proper sequence of cranks. All of the camshafts are shifted by means of a single pneumatic cylinder operating sliding sleeves similar to the one just described, except for the addition of a set of jaws on the camshaft which register with jaws in the sliding sleeve in its extreme positions and take the driving effort. The work of the spiral grooves is thus confined exclusively to shifting the camshaft. As in the two-cycle engines only a single cam is provided for each valve. This method of reversing has been applied to several engines and acts as satisfactorily in the case of the four-cycle engines as for the two-cycle.

The method of starting a Diesel engine which is almost universally used is by means of compressed air, and in most cases the air enters the working cylinders.

In starting, the air is ordinarily turned on for only a few seconds and in a few seconds more the engine can be brought right up to full power if desired. In fact, with a perfectly cold engine, the operation will be a great deal smoother under a moderate load immediately after starting than it will be at a very light load. This applies particularly at low speeds. For stationary engines which operate at full speed only, this condition is not encountered because the engine is brought up to full speed immediately after starting and the flywheel has inertia enought to keep the engine running smoothly even though ignitions are somewhat irregular.

In a marine engine the case is entirely different. Here it may be desired to start an engine slow ahead or astern, which, with a small, light, high-speed engine is difficult, unless a clutch between the engine and propeller permits the engine to be started up independently, warmed up, and then the clutch thrown in. The trouble in starting up when the engine is connected directly to the propeller is that in order to get the first ignition the fuel is turned well on, and when the first ignition does come there is enough energy in the combustion to overcome the inertia of the parts and drive the engine up to a much higher speed than is desired. With large, heavy engines this tendency is not nearly so marked and it is possible to get a slow, smooth start.

There are several ways to assist in getting a smooth start on a cold engine, and it is important to follow one of them in the case of large engines. One method is to heat the jacket water by turning steam in from an auxiliary boiler. In this way the cylinder walls can be warmed up to something approaching the working temperatures, and a smooth start is easily made. Another method, particularly useful in installations where very heavy fuels are used, is to start with a lighter fuel. By a lighter fuel is meant one that ignites readily and is more easily broken up so as to expose more surface to the heated air in the cylinder in the compression space, and thus give a quicker ignition. The solution to the problem of getting a good, smooth start consists essentially in having the temperature in the cylinders approximately the same as under working conditions and then injecting the fuel positively and regularly. Any method which does this will solve the problem.

Generally speaking, stationary engines and marine engines with clutches between the engine and propeller are fitted with starting valves on only half of the working cylinders. This means that while the engine is being turned over by starting air on part of the cylinders, the others are being warmed up by the compression, and even under very adverse conditions they soon reach such a temperature that ignition is obtained. In the case of reversing engines, the handling gear is sometimes modified to cause the starting air to be turned on and off the cylinders in groups.

The question of maneuvering is principally one of obtaining sufficient starting-air capacity, either by carrying a large number of flasks or—a much better way in the case of a large ship—by having an auxiliary compressor unit of good capacity. While the ship is maneuvering, the compressor unit is kept running all the time and pumps into the starting flasks. With such a provision an engine can be reversed repeatedly with only a very small starting-flask capacity.

In the case of small powers, it is much more convenient to use a clutch between the engine and propeller and employ a non-reversing engine which is kept running all the time.

The charge is often made against the Diesel engine that it is impossible to slow it down materially. This is true to a cretain extent of the ordinary type of construction, but with the proper modifications any Diesel engine can be made to slow down and operate as readily at the lower speeds as at the higher. The solution of the problem consists in having a regular enough turning moment to keep the engine running fairly smoothly, and to obtain definite and regular ignitions in the cylinders. The case is much simpler for a large, heavy engine which has a big mass in the moving parts, and where there are a large number of cylinders, say, at least six for a two-cycle engine and eight for a four-cycle engine, than it is for a small, light engine.

In the propulsion of a ship, the power drops off very rapidly as the revolutions are reduced, and therefore, at very low speeds, the power is so small that when divided up among all of the cylinders in the engine there is not enough fuel injected into each cylinder to give regular ignitions. This can be remedied in a large measure by cutting out half of the cylinders. The load per cylinder will then be more than doubled and the engine will run with very light loads at low revolutions.

Another method consists in the control of the spray-valve lift and timing by the operator. The control mechanism is so arranged that the timing and lift are changed at the same time. In some cases the valve is made to open at the same time under all settings and to close earlier, while in others it delays the time of opening by the same amount the time of closing is shortened. Both systems appear to work satisfactorily. When it is desired to slow the engine down, the fuel supply is reduced, the spray-valve lift reduced and the timing changed, and the spray-air pressure reduced somewhat. The combined effect of all these is to give regular ignitions in the cylinders, hence a smooth turning moment and good control over the engine. This method is much more preferable to cutting out some of the cylinders at reduced power, since it provides more impulses smaller in size and at closer intervals, which are all very vital points when running at very low speeds.

The advisability of fitting some sort of gear for controlling the timing and lift of the spray valve depends upon the type of engine and the place where it is going to be installed. Without such gear, an engine can be slowed down to about half speed without difficulty, hence for installations of small power in ships having a maximum speed of 10 knots or thereabouts it is unnecessary, because half speed means little more than steerageway. On the other hand, in the case of ships having a higher maximum speed such as 15 or 20 knots, it is very desirable to be able to slow the engine down to quarter speed or less, and then the installation of such a gear becomes almost a necessity. Under some circumstances, of course, it might be considered better to sacrifice maneuvering ability for the sake of simplification, but on engines of the size used on seagoing ships, the slight added complication due to this gear seems every bit worth while.

The question of lubrication is one that is dependent upon the type of engine. The gravity system is used successfully on large, open-frame, slow-speed engines, while on the small sizes, particularly where the crankcase is enclosed, a mechanical oiler is often used with leads to separate bearings or else a system of forced lubrication. There is one difficulty with the gravity lubrication and the mechanical oiler, and that is that there are many parts and pipes to consider, and each pipe or lead requires a certain amount of individual attention in order to see that the proper amount of oil is being supplied to that particular part. Furthermore, with these systems only just enough oil with a slight margin is provided to cover the necessary requirements of the bearing.

The big advantage of the forced-lubrication system is that a good surplus is supplied to each bearing at all times and distribution of the oil is secured by the proportions of the various passages, and hence requires no attention on the part of the operator other than to make sure that the main supply to the engine is kept up. Of course the various passages must be kept clear and open, but this is a matter that can be readily attended to during the overhauling period, and there is very little tendency for the oil to plug up the passages during operation.

There is one thing in connection with forced lubrication that is extremely important and requires constant watchfulness on the part of the operator, and that is the question of salt-water leaks into the lubricating oil. Any leak into the crankcase, no matter how small, forms an undesirable mixture with the lubricating oil,

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[1]Engineer, Electric Boat Company.

and at moderate temperatures creates a deposit which will quickly plug up the passages. If special precautions are taken against the leakage of the salt water into the oil, and the condition of the oil is watched carefully at all times, there is little chance for difficulty in this direction. From every other standpoint forced lubrication has the advantage over other methods. The proof of this is best shown by the increasing adoption of this system on engines of all types and sizes.

With an open-frame engine and using special precautions so that lubricating oil from the working cylinders does not drip into the crankcase, the oil does not become foul except after long service, but with the closed-crankcase trunk-piston engine the lubricating oil soon becomes fouled with finely divided carbon particles. After a time the oil turns very black and viscous and tends to clog the oil passages. This requires as much as 3,000 hours' running in some cases, while in others this condition obtains in a few hundred hours. It is understood, of course, that oil is added from time to time to make up for the losses, but the system is not cleaned out and the whole supply replenished in all this time. As this condition of the oil is approached the danger of bearing troubles increases, and if it can be avoided the oil ought never to be allowed to get into such a condition.

Most of the carbon particles are removed by filtering, and the filtered product approaches the original in all its properties except that it is darker, due to the presence of the particles, which were not removed by filtering. The centrifugal process of clarifying is even better than filtering and removes a larger proportion of the carbon particles.

To attempt to filter or clarify the oil each time it is circulated through the engine would imply the addition of too much apparatus to take care of such a quantity of oil, and, fortunately, it is unnecessary. The best way is to drain out the system at regular intervals, depending upon the type of engine and the conditions of the service, and fill up with fresh oil. The fouled oil can be filtered at leisure and kept for future use.

The Diesel-engine industry is still so young that the question of how large an engine can be built is one that cannot readily be answered at this time. Practically all of the engines in service today are of small and moderate power as compared with certain steam plants, but, on the other hand, big strides have been made in the last few years in the development of large units.

In view of what has already been done and the experimental work that has been undertaken by so many firms, it is undoubtedly only a question of time when Diesel-engine power will be available for all except the very fastest liners and warships.

The vibration produced by an engine depends largely upon the number of cylinders and upon their arrangement. In commercial work, generally speaking, the speed is slow enough and the hull heavy enough so that the matter is not one of great importance; but in the case of a high-speed engine in a light hull, it is absolutely necessary that the engine be properly balanced.

For commercial work, many four-cylinder, four-cycle engines have been built, and these engines are very badly out of balance due to arranging the cranks all in one plane to get the best turning moment. But, as already stated, where these engines have been installed no serious difficulty has resulted, due undoubtedly to the relatively low revolutions and the small size of the engine as compared with the hull.

If good balance is desired, it is necessary to use six or eight cylinders, which can be made to give the best turning moment and a good balance at the same time. The only thing that interferes with giving these engines a perfect balance is the air-compressor cylinders, but the reciprocating parts of these compressor cylinders are comparatively light, and hence do not cause any serious difficulty. In the case of crosshead engines it is oftentimes convenient to drive the compressors by beams and links from the crossheads. On a six-cylinder, four-cycle engine, for instance, there might be three compressors driven from three of the cranks, or on a six-cylinder two-cycle engine three compressors would be driven from three of the crossheads and three scavenger pumps from the other three, so that a practically perfect balance would be obtained.

The usual method for the fuel system is to carry the main supply of fuel in the double bottom or in tanks in parts of the ship that are not ordinarily otherwise used, and then provide pumps for pumping it into gravity tanks placed well up in the engine room, so that the fuel can flow by gravity from the tanks to the engines. The tanks are made large enough to hold at least several hours' supply, and oftentimes a whole day's supply, so that the fuel has plenty of time to settle, and any sediment or water will collect at the bottom of the tank, where it may be drained off. It is very necessary that the fuel supply to the engine be perfectly clean. Very small particles of dirt or foreign matter will stick in the valves on the fuel pumps on the engine and cause no end of trouble. There is only one way to avoid getting this dirt into the engine, and that is to filter the fuel properly. The filter is sometimes placed between the gravity tank and the engine, and is sometimes combined with the gravity tank. In case the gravity tank is of small capacity, it is generally placed on the discharge side of the pump which pumps the fuel from the main tanks to the gravity tank.

The arrangement of the exhaust piping depends upon the type of the boat and the conditions of the installation. In the case of small boats, where the water line is more or less fixed and very little rough water is encountered, an underwater exhaust works out very satisfactorily, but in the case of large ships, the exhaust must be carried up a stack. In twin-screw boats it is essential that the exhaust from each engine be kept separate so that it can be watched by the operators. One of the simplest methods of detecting faulty operation in a Diesel engine is to watch the exhaust. The least sign of smoke is a sign of poor combustion and should be investigated at once.

Many varieties of muffler are used. The main idea of all of them is to break up the pulsations in the flow of the gases and give a steady flow. Where there is plenty of space and weight available, a big expansion chamber serves fairly well, but it is much better to reduce the size and use baffle plates. One of the best types is one in which the gases enter a cylindrical chamber tangentially at the circumference and escape at the center, or vice versa. Cooling the gases by turning the cooling water from the engine into the exhaust pipe helps too, but is not used except in some special cases. If there is very much sulphur in the fuel, water combines with the products of combustion and forms sulphuric acid, which will in time destroy the exhaust piping. If, however, the entire quantity of the cooling water passing through the engine is turned into the exhaust, the mixture is so dilute that there is little danger of trouble.

The piping itself must be jacketed or lagged, and due allowance must be made for expansion. Water jacketing is, in most cases, more satisfactory, but it adds to the complication and cost of the system, and for that reason is oftentimes avoided and the pipes are lagged.

The question of cooling the various parts of a Diesel engine is an important one, but as far as the fixed parts are concerned the problem is simple for all ordinary sizes of engines. It is only necessary to provide for the proper flow of the cooling water, avoiding all pockets and dead areas. In the case of nearly all two-cycle engines and in four-cycle engines of quite moderate size, it is necessary in addition to cool the working piston, and herein lies a real problem. There is no exact dead line below which cooling is unnecessary and above which cooling is necessary, as a great deal depends upon the conditions of operation; that is, a high-speed engine designed to be driven at a heavy overload might require cooling, while the same engine driven at a lower speed and moderate power would operate perfectly satisfactorily with uncooled pistons. It is simply a question of carrying away the heat absorbed by the top of the piston. If it can be carried off fast enough through the cylinder walls to keep the center of the piston head from getting too hot, then the pistons do not need to be cooled, but if this is not so, then the extra heat must be absorbed by the circulation of a cooling medium through the piston. In general, it may be said that two-cycle engines developing 50 b.hp. or more per cylinder, are better off with cooled pistons.

The difficulties in the wake of successfully cooling the piston are best shown by the variety of substances used and by the various devices employed to carry the substance to and from the piston. The simplest method is to employ a jet of air, but this is not very effective and can be used only where the cooling effect required is very slight. The other three substances employed to any extent are lubricating oil, fresh water and salt water. Lubricating oil has the distinct disadvantage that its specific heat is only about 0.4 of that of water, and hence about 2½ times as much must be circulated to carry off the same amount of heat within the same temperature limits. In addition, oil does not absorb heat from, or give heat to, a metallic surface as readily as does water. The one advantage of oil is that in case of any leakage inside of the crankcase, it mixes with the other lubricating oil and does not cause any damage.

In view of all this, it is readily understood why lubricating oil is used only in special cases where certain conditions make the advantages more than outweigh the disadvantages.

For commercial work it is safe to say that the choice lies between fresh and salt water. Fresh water requires an additional system, including tank, pump, cooler and piping, but it is not so corrosive, not so destructive to the packing in the joints of the system, not dangerous as regards deposits in the piston, and in case of leakage into the lubricating oil there is not the danger of damage to bearings. When salt water is used with proper precautions, most of the advantages of fresh water disappear; but it is a question as to how far these precautions can be successfully carried out under every-day working conditions. Both fresh and salt water will undoubtedly be used for some time to come until enough experience is gained with both systems to finally settle the matter either one way or the other, or it may be that fresh water will be used for high-grade installations, and salt water where first cost and simplicity are of prime importance.

To carry the liquid to and from the piston there are three general systems, but the details for any one system are varied greatly by the various engine builders or by the same builder on different engines. One system is to combine the cooling with the lubrication system, but this, of course, is applicable only in case lubricating oil is used for cooling. The general scheme is to supply the oil to the main bearings, from whence it passes through the hollow crankshaft to the crank-pin bearings and up the connecting rods to the wrist pins, thence through pipes or passages in the piston to the head and back again through a pipe or passage to some point near the bottom of the piston from where it can drain directly into the crankpit. A certain amount of oil leaks out at the bearings, and this serves to lubricate them.

A second system is to use jointed swinging pipes, and a third system, telescopic pipes. Both inlet and outlet pipes can be, and are generally, used so that any liquid desired can be employed for the cooling medium. The swinging pipes are suitable for slow-speed engines only, as at high speeds the inertia forces are very large and it is troublesome to take care of them properly. Moreover, the passage for the liquid must by the nature of the case have several bends and turns, and at high revolutions the inertia forces produce extremely high pressures, making it very difficult to keep the joints of the system tight.

There is one principle that must be followed in the design of swinging pipes for even moderate speeds, and that is to keep the bearings at the joints of the pipes entirely independent of the stuffing boxes, or, in other words, the piping for carrying the liquid, and the strength members for taking the inertia forces must each do its own work, although they are fastened together and are a part of each other. The great trouble with this system is to keep it tight at the joints, and it is only by careful designing along the lines stated that successful results can be obtained. In case water is used for a cooling medium, the lubrication of the bearings at the joints becomes important, but with forced lubrication there is generally enough oil flying around in the crankcase to take care of this if pockets, connected to the bearings, are provided for catching it.

Telescopic pipes are adaptable to both high- and low-speed engines. All parts are moving in line with the cylinder axis, and taking care of the inertia forces is much simpler than with the swinging links. Moreover, there are fewer turns in the passages for the cooling medium, and, as a general thing, air chambers can be placed so as to effectively care for the surges in the cooling liquids. An air chamber on the suction side is a necessity, but on the discharge side it may be dispensed with provided the discharge pipes are of generous size. It is good practice to put an open-end pipe discharging into a funnel, with proper provision against splashing, on the discharge line so that the cooling fluid coming from the piston can be actually seen by the operator. A certain amount of flexibility in the telescopic pipes is desirable, in order to remedy any slight looseness of the piston, or of the crosshead in its guide, or any slight misalignment. One method of accomplishing this is to provide a double pipe, one inside of the other. The inside pipe is fastened at one end to the piston or crosshead and at the other to the outside pipe. The outside pipe is guided in the part fixed to the engine frame. Here again the most troublesome part is the packing, but it is like packing the piston rod of an engine, and, as might be expected, the most satisfactory packing is of the labyrinth type, with provision for self-adjustment to the pipe so that it fits snugly under all conditions.

Hooking the first cable to the block

The wrecking boat listing under the weight of the raised barge

Salvage Work in New York Harbor

Raising of Sunken Barges and Other Harbor Craft a Frequent Necessity

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At least twice during recent months there have been salvage operations of considerable magnitude conducted in New York harbor, on transports that can properly be classified as liners. The St. Paul, it will be recalled, rolled over on her side in her slip and gave the rescuers some anxious moments before they got her on an even keel again; and shortly thereafter, another big ship sunk at the dock and had to be raised.

These two operations verged upon the spectacular; in each case the salvors were in a measure treading new ground. But it is a fact that the port of New York presents quite a field for salvage work of a more or less cut and dried nature—that is to say, cut and dried from the standpoint of the blase wrecker who would count as a novel experience nothing less than the raising of a Lusitania.

There is so much traffic passing up and down the North and East Rivers and through the various lanes of the Upper and Lower Bays that accidents more or less analogous with those that happen on crowded streets are bound to be more or less frequent. It was only the other day that the Aquitania sliced the bow off an innocently bystanding freighter; and the sinking of barges and lighters, while hardly an every-day occurrence, might reasonably be characterized as an every-week one.

Accordingly the methods of salvage in such a case are more or less standardized. The main difficulty lies in the establishment of an adequate liaison with the sunken craft. New York Harbor is not filled with the sort of water that the average citizen would like to have in his bathtub on the occasion of his Saturday night ablutions; sewers have emptied their unsavory contents into it, and garbage and other filth has been dumped into it, and brought back to it from the deep water by the tides, until the condition of the harbor waters beggars description. It is literally true that a diver cannot see his hand before his face in these murky shallows, but has to work entirely by sense of touch.

Diver inspecting the salved barge on its arrival at the surface

This makes it always a matter of uncertainty just how long it will take to get lines attached to a sunken barge. The divers go down with the big loops of cable and fumble about until they get them passed beneath the bow or the stern. Then they fumble about some more until they get these loops slipped back through the slime of the bottom to their proper place along the longitudinal section of the craft under treatment. Then their work is done, save for a final trip under water after the lifting has commenced, to ascertain whether everything is going well under the application of the strain.

Archimedes it was who said that if he had a place to stand on he would undertake to move the earth with a lever; and the modern salvor has his own version of this pretty boast. Given a place to stand his cranes, he will undertake to raise anything around which he can pass a cable. But the question of a place to stand on often causes more or less of a puzzle.

On rare occasions, when a barge sinks at her moorings, it is possible to lift her out from dry land. In other cases she is large enough to demand that she be straddled in her sunken position by two wrecking craft, so that the load will be centered as she is broken away from the bottom. But when she is reasonably small and lies reasonably clear, the method illustrated in the accompanying photographs may be employed. It will be observed that this method consists in mounting a single crane on a big flat-bottomed foundation, and hauling the sunken vessel out of the mud by main strength and awkwardness, regardless of the fact that the foundation lists rather badly under the application of the load. The amateur boatman who has seen a skiff nearly or quite capsized by one swimmer clambering over the gunwhale may be distrustful of this procedure, but he might venture upon the wrecking barge with complete assurance that the strains had been figured out carefully in advance, and found insufficient to roll her over.

The cranes and tackle employed are not without their interest. One of our cuts shows quite clearly the universal ball-and-socket joint by means of which the ability of the crane to "go get 'em" in any position is enhanced. And the blocks and hooks by means of which the lines that go about the submerged hull and secured to the crane are among the giants of their kind.

A word might also be said with regard to the necessity of getting an even pull and an even strain on all the cables. One of our leading bridge engineers tells of eye-bolts which ought to be exactly of the same size and are not, with the result that the shortest bolt in a given sheaf has to bear, unaided, the strain intended for distribution among them all, until it has been elongated by that strain to a point where its brothers can come into play. The same principle holds in hauling a few tons of coal barge to the surface by means of a number of cables. Unless the matter is adjusted to the utmost nicety, some of the cables will bear more, and others less, than their proper share of the load.

There are various schemes for securing the necessary compensation between the several cables. The general idea of having all the cables in one piece, so that slack runs from one to all the others, would serve well enough, were it not for the obvious fact that under this arrangement, if one of the cables break, all of them are going to run out and drop the load back into the mud. So devices for securing automatic compensation between the several sources of motive power for the several cables are more in favor. Obviously, this adjusts the matter; for the strain on the various loops of cable is just as much a matter of the force with which we pull upward on them as it is of their lengths. So if we get to pulling too hard on one, causing it to carry more than its fair share of the load, our automatic governor compels us to lessen the pull on that cable and distribute the excess load among the others.

High Temperature in Engineering

Modern advances in scientific research can never fail of interest to those engaged in scientific industry. The gulf between science and industry is being rapidly bridged. Industrial applications of new scientific methods are eagerly sought, and new discoveries awaken interest in their industrial possibilities. This becomes especially marked in industries in which the demands are both wide and rigorous. Among such developments the production of high temperatures and their applications in engineering stands out conspicuously. In numerous directions high temperature processes have rendered possible advances in engineering which could not have been achieved so effectively by any other method.

To the lay mind the temperature of a blast or steel furnace would be regarded as "high," but in the light of modern work such temperatures provide merely

a starting point for ascending the high-temperature scale. Adhering closely to engineering applications, it may first be noted that the temperature of a solid fuel furnace is of a strictly limited order. Under the most rigid conditions, using the minimum excess of air, and avoiding the escape of more than a trace of carbon monoxide, such furnaces cannot exceed 1,500-1,600 deg. C. The melting point of platinum, viz., 1,752 deg. cannot thus be reached. With ordinary gaseous fuels no great advance of temperature is attained, as, though both gas and air supply admit of preheating and the correct proportion of fuel and air used, the calorific power is usually low, and considerable volumes of inert nitrogen are involved. The use of oxygen in place of air is at once calculated to mark a considerable increase in temperature by reason of the absence of so large a proportion of inert and heat-absorbing and therefore temperature-reducing nitrogen.

OXYGEN-FED FLAMES.

Passing up the temperature scale, the oxyhydrogen flame provides the next definite point. Long ago the flame was used by Deville for extracting and melting platinum, a method in continued use at the present time. A correctly proportioned mixture of gases gives a temperature of 2,200 deg. C., obtainable in furnaces of limited capacity. This high temperature soon found application in the production of brilliant illumination by impinging on to a block of lime, the method long holding a premier position for projection illumination. More recently the temperature of the oxy-hydrogen flame has found application in the melting of silica for filaments and the silica ware which exhibits remarkable properties, in virtue of which it is so largely applied in the chemical industries for dishes, coils, tubes, etc. Pure silica softens at 1,800-1,900 deg. C., and runs easily at 2,000 deg. C. The flame, too, is employed for autogenous welding and metal cutting, the gases being proportioned to give reducing and oxidising flames in the respective cases. Considerable thicknesses of metal can thus be cut as cleanly as with a tool. But a limit to the temperature of the oxyhydrogen flame is set at 2,200 deg. C., this being the dissociation point of steam, beyond which temperature no combination occurs. A higher temperature will be possible where the products have a higher dissociation point. The substitution of acetylene for hydrogen brings a marked advance in temperature up to and even beyond 2,500 deg. C. This is due to the higher dissociation point of carbon monoxide, a primary product of the combustion of acetylene. But a further cause contributes to this higher temperature. Acetylene is an endothermic substance, carrying latent energy in excess of that of its individual constituents. This arises from its close affinity to and production from calcium carbide. The formation of carbide is only possible under conditions admitting of great heat absorption, and the high temperature of the electric arc is essential to this. The energy thus rendered latent is partly evolved in the generation of acetylene by the contact of carbide and water, but a large proportion still remains in the acetylene to the extent of approximately 58,000 calories per 26 grams of the gas. Upon combustion this energy is transformed into heat in addition to that ordinarily set free from the already highly calorific constituents. Numerous applications of the flame have been made, and the engineer has been equipped with a chemical tool of enormous use, and the cutting of 12 in. armorplate by such a high-temperature flame of small dimensions is a striking example of its possibilities. For this purpose an excess of oxygen is employed, resulting in the oxidation of the metal and the blowing away of the easily-formed and more readily-fused oxide.

THERMIT.

The limiting temperature conditions of the oxyhydrogen and oxyacetylene flames are, however, capable of considerable extension by the use of combustibles and supporters of combustion-giving products of considerably higher dissociation points, such as the aluminium and oxide of iron contained in the usual thermit mixture. This mixture ignites readily, burns vigorously, and develops a large amount of heat which raises the products—iron and alumina—to a temperature of at least 2,500 deg. C., and considerable advantages accrue from this in the application of the mixture to the welding of rails, and welding repairs to heavy work in situ. A further application is found in the production of carbonless refractory metals, such as chronium, tungsten, etc., by substituting their oxides for that of iron oxide in the thermit mixture. The use of mixed oxides, too, admits of the production of a large variety of alloys, practically pure, except for a trace of aluminium.

Still further ascending the scale of industrial temperatures, the carbon arc at ordinary pressures provides the next point at about 3,450 deg. C., while under pressure this may increase to 3,600 deg. C.

THE ELECTRIC FURNACE.

In the electric furnace large supplies of electrical energy can be transformed into heat in a very small compass, thus developing very high temperature. This may result from a solid, liquid, or gaseous conductor. With a solid or liquid conductor the furnace is of the "resistance" type, while in an "arc" furnace carbon vapor usually constitutes the medium in which the heat is generated. Resistance furnaces offer the possibility of a very wide range of temperature from that required for the fusion of a low melting point metal to the high temperature developed in a carborundum furnace in which a large quantity of the abrasive is produced by the interaction of sand and coke, under the influence of heat generated in a solid core of carbon. Siloxicon—a compound of silicon, oxygen and carbon—is simultaneously produced from the same materials, at a somewhat lower temperature, obtaining at a greater distance from the carbon core. Siloxicon finds application as a furnace lining. The same type of resistance furnace serves also for the production of artificial graphite, now largely used as an electrode material in many electro-chemical and metallurgical operations. In such resistance furnaces the heat is developed either in, or directly in contact with, the material to be treated, thus avoiding the usual high losses of transmission through thick walls of refractory material. The temperature gradient of such a furnace, while steep, is not so steep as that of the arc furnace, in which the heat is developed in a large carbon arc. Simple types of arc furnace comprise two carbon blocks, which constitute the electrodes, one of which may frequently be replaced by the conducting lining of the furnace or of the material under treatment. Such furnaces, simple in general design, may vary widely in detailed construction, and can be used for either continuous or intermittent running. The production of calcium carbide is well known, and ordinarily demands a temperature of 3,300 deg. C., though an additional 100 deg. C. may bring about the decomposition of the carbide with the precipitation of carbon as graphite and the volatilisation and loss of calcium. In a similar furnace silica is reduced by carbon to silicon, at present largely used in the production of silicon steels and of hydrogen for industrial purposes.

Other important electric furnace products are ferro-alloys made by reducing the refractory oxides with carbon in the presence of excess of iron. Of these materials many are indispensable in the manufacture of special steels for engineering work, on account of their very favorable properties. Thus, ferro-silicon deoxidises steel, and may also be used to give the correct control of silicon in cast-iron. Ferro-chromium is required for chrome steel, used on account of its hardness for armor plate, high speed tool steels and projectiles. Ferro-tungsten is in special demand for high speed steels. Ferro-vanadium increases the strength of steel, while ferro-molybdenum gives essential properties to steel used for cutting purposes, for large guns and rifle barrels. The furnaces in which these alloys are made usually comprise both arc and resistance heating, and the same may be said of the furnace designed by Heroult for the electric manufacture of steel, in which two substantial electrodes produce separate arcs with the slag floating on the surface of the steel, the current between the arcs being conducted through the molten bath.

Mention should also be made of the various types of electric furnaces in which carbon electrodes are not used, but in which the heating current is produced in a single or double ring of metal contained in an annular trough, the current being set up by induction. Steel furnaces designed by Kjellin, Rochling-Rodenhauser, and others illustrate this type. In addition the smelting of iron ores electrically has made great progress, many advantages accruing from electric heating where power is cheap and solid fuel scarce, and in the cases cited above high temperature processes have been found most effective in the production of materials which play a large part in modern engineering.—From *London Times Engineering Supplement.*

The huge crane and cables used in salvaging sunken coal barges in New York harbor

Soy Bean Milk

It is well known that many thousands of tons of soy beans have been imported into this country for the sake of the contained oil, which is used in the manufacture of soap, margarine, etc. More important, perhaps, from the alimentary point of view is the fact that it can be used to yield a substitute for cow's milk, which closely resembles the latter both in composition and properties. The method of preparation is very simple: Five ounces of the beans are soaked overnight in a quart of cold water; they are then coarsely ground, mixed with the water in which they have been soaking, and filtered through muslin. The result is a milky fluid with a rather strong smell of haricot bean, which disappears after it has been raised to boiling point. It closely resembles milk, contains 3.13 per cent casein and 9.89 per cent fats, but lacks carbohydrates. Cheese can be prepared from it, 120 gms. of the bean yielding 184 gms. of cheese. The residue after making milk can be worked up into diabetic biscuits.—*Brit. Med. J.*

Alcoholic Fermentation of Banana-Must

Earlier work on the chemistry and bacteriology of the *Musa sapientum* banana is summarised. To obtain a must which will retain after fermentation, the flavor of the fruit, the skins as well as the pulp must be extracted. From such a must the author isolated four organisms: a *Saccharomyces* predominant in the fermented liquid and designated *Sacch. musae*, a bacterial form abundant in the liquid, a variety of *Oospora lactis*, and a *Mycoderma* form. Particulars of these organisms are given. From an experiment on the fermentation of an extract of skins and pulp, with *Sacch. musae*, it appears possible to produce from the banana, by adding sugar to the must, and perhaps purifying after the primary fermentation, a fermented liquid of good color, slightly alcoholic, and of attractive qualities among which the agreeable aroma of the fruit holds first place.—*Note in J. Soc. Chem. Ind. on a paper by R. Perratti and V. Riviera in Statz Sperim. Agrar. Ital.*

The Dustfall of March, 1918*

Conclusions as to the Possibilities of the Wind as a Geologic Agent

By A. N. Winchell and E. R. Miller

SOME of the snow which fell at Madison, Wisconsin, on March 9, 1918, contained sufficient foreign material to change its color from white to a light brown or yellow. It was observed under conditions which permitted a close study and the collection of some evidence and data regarding the material. It is the object of this note to put these data on record, and to discuss the quantity, nature, and probable source of the coloring matter.

The colored snow came down at Madson in the form of moist snow mixed with sleet, during the passage of an unusually intense and fast moving cyclonic disturbance. It fell from 11:30 A. M. to 2:30 P. M., 90th meridian time, but the proportion of coloring matter is believed to have been greater toward the end than at the beginning. The moist snow and sleet were preceded by rain, from 9:30 A. M. to 11:30 A. M., which froze as it fell, and remained as a sheet of ice about ⅝ inch thick on trees, wires, etc. The moist snow and sleet were followed by dry snow from 2:30 P. M. to 9:30 P. M. Neither the ice nor the dry snow contained an appreciable amount of coloring matter.

At the time of the storm the snow and sleet were observed to have a light reddish brown color, not only by the Weather Bureau observers, but also by others, some of whom called upon the Weather Bureau office for an explanation of the "dirty snow" while it was yet falling. The discoloration was still more easily seen after the pure white dry snow had begun falling and drifting into the depressions in the darker layer. On the second day following, when the snow began melting the dust was left on top of the snow.

Area of fall.—The evidence obtained as to the area covered by the dusty snow fall is admittedly incomplete and inconclusive. Inquiries were sent immediately after the fall to a number of Weather Bureau officials in cities. The replies from most of these indicated that the contamination of the snow by city smoke, dust, and ashes had precluded any possibility of recognizing the colored snow. Inquiries were then sent to co-operative observers of the Weather Bureau in places remote from cities, from Wisconsin, eastward to Maine. The snow unfortunately had disappeared at many of these places by the time of the receipt of the inquiry, and only one-third of those to whom the inquiry was sent had noticed the phenomenon. All told, positive reports were received from Dubuque, Ia., Grand Haven, Mich., Portage, Wis., Hancock, Wis., Montello, Wis., Florence, Wis., Newberry, in upper Michigan, and Chelsea, Vt. The location of these points, where dust was observed, is indicated by dots on the outline map (Fig. 1).

Nature of the coloring matter.—A microscopic study of the coloring matter separated from the melted snow shows that it consists chiefly of inorganic substances, but contains also some plant tissue. All of the material forms a dust when dry and contains feldspar, quartz, opal, limonite, hematite, hornblende calcite, mica, magnetite, apatite, tourmaline, zircon. There is also some cloud-like material which may be kaolin. From Rosiwal measurements[1] the proportion of the chief constituents has been estimated to be: feldspar and quartz 65 to 75 per cent.; amorphous material, including limonite, hematite, kaolin, opal, etc. 20 to 30 per cent.

The feldspar fragments are remarkable on account of the fact that they show no alteration whatever; they are as glassy clear as is the quartz. Both the quartz and feldspar are stained by limonite and hematite, and this condition seems to pervade the fragments so thoroughly as to indicate that it is a condition of long standing. The feldspar shows no twinning and much of it is probably orthoclase, but other feldspars are not excluded. Calcite, hornblende, mica, etc., are present in very small amount. Magnetite particles were discovered by using a magnet.

In addition to the minerals and organic material, this snow dust contains a considerable number of diatoms. There seems to be more than one kind of diatom present, and the sizes vary, but the usual size in this dust is 0.006 to 0.01 mm. in width, and 0.02 to 0.035 mm. in length. They are roughly cigar-shaped and so small that it would require 750 laid end to end to measure one inch, and more than three billions to fill one cubic inch. The portion of the diatom found in the dust is the test, which is composed of hydrous silica, or opal, and has various very regular markings over its surface.

Microscopic measurements of the size of the dust particles show that they range from about 0.003 mm. to about 0.1 mm., but a surprisingly large percentage falls within much narrower limits, namely 0.008 to 0.025 mm.

Fig. 1. Localities where the dustfall was observed

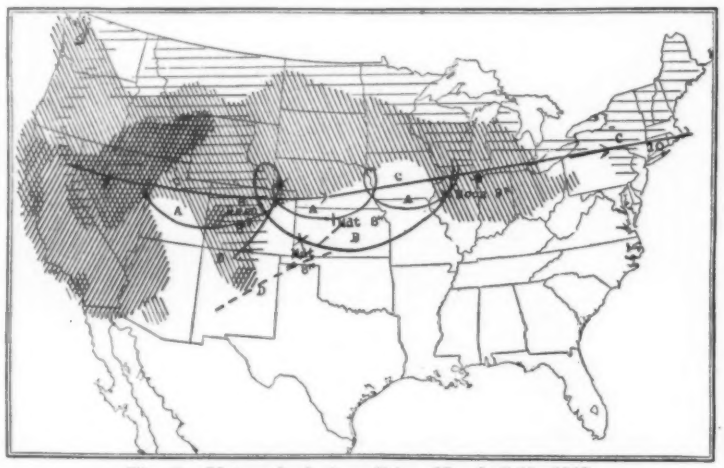

Fig. 2. Meteorological conditions March 7-10, 1918

Curve C shows path of center of storm of March 7-10. Curves B, A show trajectory of upper air current that arrived at Madison, Wis., at 11.30 A.M., 2.30 P.M., respectively, March 9. Curve D shows conjectured trajectory of dust-bearing lower current ascending to upper stratum. Horizontal hatchures show snow-cover 7 P.M., March 4, 1918. NE-SW hatchures show area of rainfall during 24 hours preceding 7 A.M., March 8, 1918. NE-SE hatchures show area of rainfall during 24 hours preceding 7 A.M., March 9, 1918.

At our request, a mechanical analysis of the material was made by Professor H. W. Stewart of the Soils Department of the University of Wisconsin. He reports that the water-free weight of the sample used was 1.8268 grams, and that it yielded the following:

Separates.	Size.	Per cent.
Clay	Less than .005 mm.	11.145
Fine silt	.005 to .010	22.005
Medium silt	.010 to .025	56.169
Coarse silt	.025 to .050	5.988
Very fine sand	.05 to .10	1.215
Fine sand	.10 to .25	1.035
Medium sand	.25 to .50	0.580
Coarse sand	.50 to 1.00	0.290
Fine gravel	1.00 to 2.00	1.078
Total		99.504

Professor Stewart reports also that the organic constituents were allowed to distribute themselves wherever they would among the separates, with the result that much, if not all of the four largest sizes consist of organic material, and the very fine sand includes both organic and inorganic matter.

The organic constituents were so obviously plant tissue that they were submitted to Professor R. H. Denniston of the Department of Botany, who reports that they include fragments of blades of grass, of leaves of clover or some similar legume, fibers of cotton, and fragments of coniferous wood, all more or less decayed, as shown by the presence of saprophytic fungi and their spores. The only inorganic material in the so-called "gravel" consists of white particles which effervesce with acetic acid; it is therefore a carbonate.

An attempt was made to separate the consituents of the dust by means of a heavy solution of potassium mercuric iodide. Most of the material sank in a liquid of specific gravity of 2.3, but the material still floating contained the same materials as the part which sank. A portion of the dust separated by mechanical analysis to the size of 0.010 to 0.025 mm. was tested in the same way. Practically all of it floated at 2.7, less than one quarter of it sank at 2.6; again the two parts contained the same materials; the heavier seemed to contain less limonite stain than the other. It seems probable that submicroscopic porosity modifies considerably the apparent specific gravity of much of the dust.

Comparison with similar analyses of soils, volcanic dust and atmospheric dust shows that the Madison dust has two peculiarities, namely, it is finer than the other dusts and it contains a large percentage within a small range of sizes. Some soils contain much larger amounts of clayey material (smaller than .005 mm.) than the Madison material, but a hasty search of the literature makes it clear that few, if any, soils contain as much silt; on the other hand shower and volcanic dust contains much less clay than the Madison dust. This may be explained as due to the fact that shower and volcanic dusts fall wholly through the action of gravity, while the Madison dust was brought down not by its own weight, but by the weight of the snow or rain condensed upon it.

No explanation is offered here for the small range of sizes within which such a large part of the Madison dust is included, other than the remarkable sorting power of the wind; perhaps this is a sufficient explanation even as compared with the shower and volcanic dust, if the size of the Madison dust is remembered.

Quantity of the dust.—Several samples of the dust were obtained at Madison. Professor W. H. Twenhofel collected the yellow snow from one sq. yd. of surface; A. N. Winchell obtained a sample amounting to 5½ liters of snow water; smaller amounts were gathered by E. R. Miller and W. J. Mead. The residue after evaporating the colored snow obtained from one square yard of surface weighed four grams, while the sample of 5½ liters of snow water yielded 5.2 grams of residue which settled to the bottom as well as .15 grams of black material, which floated at the surface or in the liquid. These two determinations are mutually corroborative since the second sample was obtained from somewhat more than one square yard of surface. They indicate that the residue amounted to 4.8 grams per square meter, or 4,800 kilograms per square kilometer; in more familiar units, this amounts to more than 13.5 tons per square mile. Observers of the U. S. Weather Bureau, quoted above, report that this colored snow fell at least from Dubuque, Iowa, to Chelsea, Vermont, in an east-west direction, and from Madison, Wisconsin, to Newberry, Michigan, in a north-south direction. This is about 900 miles east and west, and 300 miles north and south as shown by the map. It covered an area of at least one hundred thousand

*From *American Journal of Science.*

[1] A. Rosiwal. Ueber geometrische Gesteinsanalysen, Verh. k. k. Reichsanstalt, Vienna, 1898, p. 143.

square miles and probably much more. Therefore the total quantity of dust may be estimated as at least a million tons, and probably considerably more. In fact, it seems likely that the material was brought down throughout the area covered by this snow storm, and in that case, the quantity deposited would run into the tens of hundreds of millions of tons.

Origin of the dust.—While the meteorological data do not afford evidence as to the exact locality from which the dust came that was deposited at Madison, yet the possible field may be limited very materially by appealing to them.

The winds near the ground can be eliminated at once, first, because the dust was brought down by sleet, which is known to be frozen rain, that is to say, rain formed in an upper, warmer, stratum, falls through a cold lower stratum and is frozen in it; and second, because the lower wind, traced back along its course, is found to have come from the northeast, blowing only over snow-covered ground, and the waters of Lake Michigan, during the time that it was under the influence of the storm, so that it could not have blown up soil or sand.

In dealing with upper air currents, say from 500 to 2,000 meters above the ground, it is usually assumed by meteorologists, that the velocity is determined by the distribution of pressure as observed with barometers at the surface, and that the direction is along the momentary direction of the isobar. The velocity of the wind has been shown by Shaw[2] to be a resultant of the gradient velocity and the storm movement in only certain types of storms, but for the sake of simplicity in obtaining a first approximation, these conditions have been assumed in this case. Various formulas, and tables for obtaining the gradient velocity have been given by Shaw, Gold, Patterson, and Humphreys. The revised monograph of Humphreys[3] has been used in obtaining the trajectories marked A and B in Fig. 3, for the dust-bearing upper currents that arrived at Madison at the beginning and end of the observed time of the dustfall.

The storm of March 7-10, 1918, was characterized by strong winds at the surface throughout its passage from Utah eastward, so that the mechanism for eroding the surface and carrying the dust up into the atmosphere was available over a wide area. The telegraphic report of the Weather Bureau at 7 A. M. of March 9, 1918, showed high winds prevailing throughout the southwest from the Mississippi valley to the Rocky Mountains. Among the higher velocities reached during the preceding night were 48 miles per hour at Oklahoma City, 44 at Denver, 44 at Wichita. On the preceding day the storm center was advancing through Utah and Colorado and a region of steep barometric gradients and strong winds passed over the arid regions of Nevada, Utah, Arizona, Colorado, and New Mexico, a maximum velocity of 48 miles an hour being attained at Modena, in southwestern Utah.

The velocities are sufficient to blow up into the air not only clouds of dust, but to whirl up from the ground gravel of considerable size. The limit of snow cover, from the Snow and Ice Bulletin of the Weather Bureau of March 5, 1918, and the areas covered by rainfall during the advance of the storm are shown in Fig. 2. Except in Colorado, and northern New Mexico, the territory subjected to high winds was not protected in any way, aside from the natural vegetal covering, against eroding winds. The reports from observers and from military camps in the region indicate that extraordinary dust storms prevailed and caused much discomfort.

The microscopic study of the dust reveals several facts having an important bearing on its origin. First, it is well sorted and very fine. Both of these facts indicate that it has been carried a long distance in the air (according to the estimates of Udden a distance which may be a thousand miles or more). Next, the dust is charged with abundant limonite and hematite, although kaolin is not abundant and the feldspar is entirely unaltered. These facts indicate that the dust is a product of physical disintegration, and not of chemical decomposition, that is, it is derived from a region of very arid climate and not from any part of the Mississippi valley. Finally, the dust is dominantly composed of feldspar and quartz with very small amounts of other constituents. Therefore, it is derived from a region of siliceous feldspathic rocks, either granite or arkose, or a gneiss of similar composition. It is not derived from a region of limestone, sandstone, mica schist, or basic igneous rocks. It contains far too little kaolin and its feldspar is too fresh to be derived from any ordinary shale or argillite.

From all these lines of evidence it is believed that the dust came from an arid region of the southwestern part of this country, where siliceous feldspathic rocks are abundant. Such areas are common in New Mexico and Arizona. It is conjectured that the material was whirled up from the surface on March 8 in the afternoon when the convectional currents are most effective both in causing rapid vertical movements, and in increasing the velocity of the surface air by mixture with the faster moving upper air. During vertical ascent the horizontal component of velocity gradually increased, and the direction gradually veered, as shown by the dotted curve D in Fig. 3, until it coincided with the line of gradient velocity indicated by the continuous lines A and B in Fig. 3. The dust-bearing current then whirled around the storm center, in contra-clockwise direction until it arrived at the flank of the colder current flowing in from the east over the Great Lakes and the St. Lawrence valley. The warmer and lighter air from the southwest then rose over the colder and denser air from the east, and the precipitation of the moisture upon the dust particles as nuclei came about through the mechanical cooling of the ascending air. The precipitated moisture was in the form of rain at first, but froze to sleet as it fell through the cold lower stratum. Higher ascent cooled the rising air below the freezing point, and then the snow formed that fell with the sleet formed lower down. The pure white snow fell in the northeast winds, following the storm, and these probably came from the snow-covered land to the north or east.

Conclusion.—The evidence here presented that a single storm may transport a million tons of rock material a thousand miles or more, emphasizes the importance of the wind as a geological agent. Water transports larger rock fragments, and its work is readily seen on every hand; air transports much finer material and its work is only rarely noticed at all; yet the air is constantly at work over a much larger surface than that covered by running water, and it is an open question whether the total work done by the air in transporting rock material is not of the same order of magnitude as the work of the same kind accomplished by water.

It is clear that arid regions will constantly lose rock material by wind action and that the dust will be held by moist areas which are covered by vegetation. This is a type of erosion which may carry material "up hill" from a dry region of little elevation to a moist region of greater elevation. In the case here presented however, the material probably came from a mountainous arid region to an area of lower elevation.

The soil of any region is probably derived in considerable part from material transported by the wind.

Diatoms and all sorts of plant and animal life of microscopic size as well as fragments of larger organisms may be transported long distances by the wind.

[2]Revolving fluid in the atmosphere, Proc. Roy. Soc., Lond., ser. A, 94, p. 34-52.

[3]Journal Franklin Inst., November, 1917, p. 673, revised.

The Perception of Sound

ALTHOUGH the pitch of a particular tone is, say, 640 d. v. per second, it is not necessary that, in order to recognise it, we should listen to that tone for a whole second of time. Prof. McKendrick many years ago demonstrated that we could recognise as distinct from its predecessor and successor a note in a musical composition if it were listened to for only 1/64th of a second. In such a case this would mean that only ten condensations would affect the organ of Corti, and presumably only ten nerve-impulses ascend the auditory nerve. Prof. McKendrick, with whom it was my privilege to be associated at that time, studied the surface of the wax-cylinder records of musical compositions recorded for reproduction by the phonograph.

Since the speed of rotation of the cylinder was known, the number of impressions in the wax corresponding with each of a series of tones could be ascertained; and it was found that, in order to recognise any given tone, it was only necessary to "hear" that tone for not longer than 1/64th of a second. If I remember correctly, a shorter period still was in some cases demonstrated to be sufficient.

Now if, say, 1/100th of a second is long enough, it is clear that the hearing of quite high tones could be effected by a comparatively small number of vibrations or disturbances in the internal ear and of subsequent impulses in the nerve.

A tone of 2,000 d. v. per second could be recognised by 20 impulses, and one of 10,000 pitch by 100, and so on. Apparently the auditory nerve is competent to transmit individual impulses of that order of frequency.

It seems to me that attention to this point will make the problem of hearing rather simpler than at first it appears by removing the necessity for believing that, in order to appreciate a note of a given pitch, we require to have the auditory nerve transmitting the large number of impulses corresponding with the large number of vibrations which, according to physicists, is the pitch or number *per second* of that note. In other words, the different tones in a musical composition follow one another with such rapidity that no particular note is produced for a whole second, and, therefore, not perceived for a whole second.

But, on the other hand, it is clear that we can listen to a high-pitched note for a second or for a minute or for any length of time. When we are hearing a note of 20,000 d. v. per second pitch, we are almost certainly *not* receiving 20,000 impulses per second into the central nervous system. To take an analogy from vision: when we perceive red light, we are certainly not receiving anything like (395×10^{12}) impulses per second, which is the "pitch" of red light. If, in seeing colored light, such an enormous number of vibrations in the æther affect the retina, there must be something of a very different character as regards frequency, which, ascending the optic nerve, so stimulates the visual centre that we see colored light.

We have in perceptual consciousness qualitative differences corresponding with objective quantitative differences, an ever-present problem of psycho-physics; and no one has ever suggested that our optic nerves and visual centres are dealing with impulses at many millions a second. Why, then, may we not apply the same reasoning to the ear?

When we are listening to all possible tones from, say, 1,000 d. v. per second pitch to 40,000, may we not somehow have in consciousness qualitative differences corresponding with objective quantitative (arithmetical) differences? We cannot, apparently, be more definite than this.

In the case of the eye there is no conceivable possibility of an identity between the rhythm of optic-nerve impulses and that of the vibrations of the æther; is it not by analogy probable that neither is there any direct correspondence between the auditory nerve-impulses and the periodicity of sonorous vibrations?—*D. Fraser Harris, in Nature.*

Long-Range Guns

IN a recent number of the Field Artillery Journal extracts are given from a lecture delivered at the British Royal Artillery Institute by Major J. Maitland-Addison, R.A., on "The Long-range Guns," in which, he discusses the gun used by the Germans to throw shells into Paris. Speaking of the "ultimate limit" of velocity of projectiles, he explains that he uses the expression "ultimate velocity limit" for want of a better term; that the "ultimate limit" is to throw projectiles off the earth into space, such a feat as Jules Verne had in his mind when he wrote his book, "De la Terre a la Lune." "The requisite velocity is not so immeasurably higher than has already been achieved today," he said. "A velocity of a mile per second has been attained. Assuming that some day we may be able to increase this to five miles per second (a velocity only five times greater), the projectile would then travel around the earth as a grazing satellite, completing its orbit between seventeen to eighteen times daily, and with a still higher velocity of about seven miles per second, it would move off into space never to return. But it must not be pre-supposed that the dimensions of a gun are merely in simple proportion to the velocity it is required to produce. On the contrary, they increase as some power of the velocity. Nevertheless, it is a remarkable fact that such a velocity as one mile per second has been reached."

Gases in Alloy Steel

THE gases dissolved in steel consist chiefly of carbon monoxide and hydrogen. Hydrogen predominates at low temperatures, but as the temperature is raised, decreases to a minimum value, after which it again rises with further heating. Carbon monoxide is present only in small quantities at low temperature, but rises on heating to a maximum and then commences to decrease. At high temperatures carbon monoxide and hydrogen are present in more or less equal amounts. Carbon dioxide, methane, and nitrogen do not as a rule constitute more than 5% of the total gases present. The evolution of gases on boring is related to the critical points, the greatest development occurring at these temperatures. In special steels the gases present decrease as the nickel, silicon, chromium, manganese, or other special constituent is present in increasing amounts. The gases dissolved are similar to those present in carbon steels with the exception that silicon and manganese lower the content of carbon monoxide and increase that of hydrogen. Chromium appears to increase the amount of nitrogen present. As in the case of ordinary steels the largest volumes of gas are set free in the region of the critical points.—*Note in Jour. Soc. Chem. Ind. on an article by A. Stadeler, in Stahl u. Eisen.*

Newton and the Colors of the Spectrum*

An Inquiry into the Reasons for Certain of the Great Philosopher's Viewpoints

By R. A. Houstoun, M.A., Ph.D., D.Sc., Lecturer on Optical Physics at the University of Glasgow

EVERY student of optics knows that when Sir Isaac Newton discovered the spectrum he divided it into seven colors, namely, red, orange, yellow, green, blue, indigo and violet, and most students of optics have at the same time wondered why indigo was included in this list of colors. For if we look along the spectrum from the one end to the other, screening off everything except the particular strip we are examining, we see in succession red, orange, yellow, yellow-green, green, green-blue, blue, blue-violet, and violet, but between the blue and the violet there is nothing sufficiently different in kind to warrant the introduction of a new name; the other color merges gradually into the other, and the intermediate shades are clearly mixtures of blue and violet. Indigo, as we know it from the water-color paintboxes, is an inky blue, a blue inclined to black, not one inclined to violet. What did Newton understand by the color indigo, and why did he attach such importance to it?

There is no doubt, I think, that Newton introduced his seventh color partly because his own color vision was slightly abnormal, partly from a fancied analogy between the spectrum and the musical scale, influenced no doubt by Kepler's doctrine of harmonies. Also I think it highly probable that it was on account of this fancied analogy that he regarded the dispersion of all transparent substances as the same, and did not attempt to correct the chromatic aberration of lenses. It is always interesting to consider the mistakes made by eminent men, especially when they are so important for the history of science as this one was. So I propose in this paper to give an account of the evidence bearing on the matter.

We shall first of all consider Newton's color vision. This explanation has been put forward by Edridge-Green. In his theory of color vision he does not accept the usual classification of red-blind, green-blind, etc., but divides color vision into seven classes—monochromic (totally color-blind), dichromic, trichromic, tetrachromic, pentachromic, hexachromic, and heptachromic—according as the subject sees one, two, three, four, five, six, or seven distinct colors in the spectrum. According to his theory normal color vision is hexachromic; the normal individual sees the six colors, red, orange, yellow, green, blue, violet. The normal individual sees, of course, intermediate shades between these colors, but these six colors appear to be primary. The heptachromic class see indigo as a primary color, and have a decidedly better color perception than the hexachromic. It is not merely a matter of color nomenclature; the heptachromic really see something at this region in the spectrum, which the hexachromic do not see. Newton, according to Edridge-Green, was a heptachromic.

I was at first somewhat sceptical about this explanation, because Newton states in a passage to be afterwards quoted in full that his eyes were not so critical for distinguishing colors as the eyes of his assistant; also I gathered from Edridge-Green's papers that heptachromics occurred rarely, and the probability of both Newton and his assistant being heptachromic seemed to me too small. But out of eighteen cases—members of the staff and advanced students of the university—that I have recently examined I find that three at least quite definitely see indigo as a separate color, and there is a fourth case doubtful. The others are normal. So that the peculiarity seems to be fairly common.

I had no difficulty in convincing myself, somewhat to my astonishment, that the four students referred to have a much better power of discriminating hues in this part of the spectrum than I have, and my color vision is normal. They all objected to the word indigo, and chose dark blue as a more suitable name for the new color; they all said it was liker blue than violet, and their readings for the boundary between it and blue were, in $\mu\mu$, 457, 455, 465, 465, 465, the first two readings being by the same observer, and all the readings being made rapidly and without hesitation. At this part of the spectrum I see only blue merging into violet, and I find it extremely difficult to say where the one begins and the other ends, getting anything between 437 and 460 $\mu\mu$.

In his *Opticks* Newton refers to his assistant in connection with the discrimination of color, and in the *Lectiones Opticæ* speaks of himself as relying on the judgment of others. He would naturally choose others with a keen sense of color, but he would not, I think, have committed himself so definitely had he not seen indigo to some degree himself. I am therefore inclined to class him as a doubtful heptachromic and his assistant as a decided heptachromic.

Before describing Newton's experiments I should like to dismiss a suggested explanation which has been frequently offered to me by students, that indigo was introduced to make out the seven colors, that Newton was anxious to have seven colors in his list on account of some mystical significance attaching to that number. The words of Helmholtz[1] are, I think, quite conclusive on this point, namely, that to the observer with normal color vision orange-yellow, yellow-green, and sea-green, *i. e.* green-blue, are at least as different from their neighbors in the spectrum as indigo is from blue and violet. In making out a list of the seven

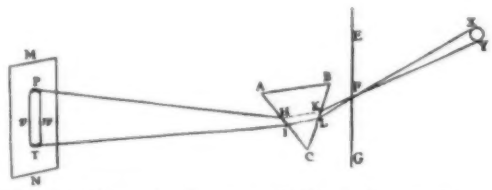

Fig. 1: Newton's diagram of his first apparatus for showing the spectrum

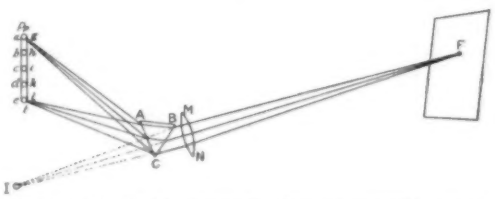

Fig. 2: Newton's approximation to present usage with the prism

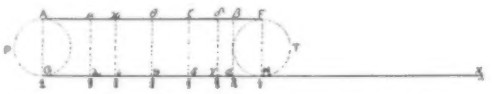

Fig. 3: How Newton divides the spectrum into seven fundamental colors

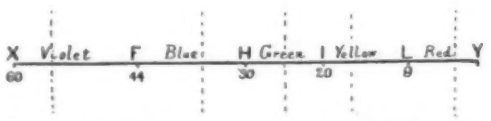

Fig. 4: An earlier arrangement in which Newton recognized but five primaries

most important colors they would have prior claims to indigo.

It was in the year 1666 that Isaac Newton carried out at Cambridge the experiments on the decomposition of white light by a prism which were to inform us as to the true nature of color. As source of light he used the brightest of all possible sources, namely, the sun. Its rays were admitted into darkened room through a hole in a shutter. In the first experiment on the spectrum described in the *Opticks*, *i. e.* expt. 3, Bk. I. Part 1, this hole was circular and about 1/3 in. in diameter. The room thus acted as a pinhole camera, and an image of the sun in its natural colors would under ordinary circumstances fall on the opposite wall of the room. If, however, a glass prism was placed inside the room close up to the hole, with its refracting edge horizontal and pointing downwards, so as to receive the rays, they were refracted, and the image of the sun appeared higher up on the wall, as is shown in the Fig. 1, which is taken from the *Opticks*. At the same time it changed its appearance. Instead of appearing as a single yellow disc, when it was received on a sheet of white paper it became a vertical strip with straight sides and semi-circular ends. This strip was colored, the upper end being violet, the lower end being red, and the intermediate portion being blue, green, and yellow. In this way Newton discovered the prismatic spectrum.

With the arrangement shown in Fig. 1 owing to the diameter of the pinhole being 1/3 in. the spectrum would not be sharp, but would have a penumbra 1/3 in. deep round its boundary. Nevertheless on account of its simplicity this arrangement seems to have been used oftener than any other. In expt. 5, p. 28, however, we find Newton taking steps to remove the penumbra, which he did by placing a lens at the hole in the shutter. The dark room then acted like an ordinary photographic camera, the lens throwing a sharp image of the sun on the opposite wall.

Even with a lens at the hole the spectrum is not pure, for every color forms its own image of the sun. Consequently we have a series of colored discs, red, orange, yellow, green, blue, violet, all with their centres at different points on the same straight line and all overlapping. The overlapping is greatest on the line of centres and least at the edges of the spectrum. The edges are, of course, defined by the two common tangents to all the discs. The spectrum is thus very impure in the middle, but increases in purity towards the edges. On pp. 46 and 47 we find Newton discussing the impurity of his spectra. He ascribes it to the diameter of the sun not being small enough, and suggests placing an opaque body with a round hole in the middle of it without doors, at a great distance from the prism in the direction of the sun. The colored images then produced inside the darkened room would not correspond to the whole disc of the sun, but only to that portion of it seen through the round hole of the opaque body. He suggests using a lens with this arrangement, the lens to be placed close to the prism and to throw a sharp image of the round hole in the opaque body on the wall of the room. And then, having reached this stage, he points out that the opaque body is not necessary; the hole may be quite as well made in the shutter itself and focussed by a lens on the other side of the room.

We find this arrangement described in expt. 11 (p. 47) and represented in Fig. 2. F is a round hole in the shutter, MN is a lens at a distance of about 10 or 12 ft. from the window, which throws an image of the hole on a sheet of white paper at I, which is at a distance varying beteen 6 and 12 ft. from the lens, according to the lens used. The introduction of the prism causes the formation of the spectrum pt. The diagram shows a circular hole at F, but on p. 49 we find:

"Yet instead of the circular hole F, it is better to substitute an oblong hole shaped like a long Parallelogram with its length Parallel to the Prism ABC. For if this hole be an Inch or two long, and but a tenth or twentieth part of an Inch broad or narrower; the Light of the Image *pt* will be as Simple as before or simpler, and the Image will become much broader, and therefore more fit to have Experiments tried in its Light than before."

We have thus the modern arrangement of slit, lens, and prism, and the question arises, why did Newton not discover the Fraunhofer lines? With a slit 1/20 in. broad and a spectrum 8 in. long they should be visible when looked at from a suitable distance, if a modern prism were used. Newton's failure seems partly to have been due to his prisms. He apparently polished them himself, and the glass was of poor optical quality; one prism he mentions as having "Veins, running along within the Glass from one end to the other." Also it seems that he did not work so often with the slit and lens arrangement for producing spectra as with the pinhole or ordinary camera methods; the motion of the sun in the sky would cause less trouble with the two latter arrangements. Besides, the years 1665-6 were a time of such great mental activity on the part of Newton—they saw the discovery of the binomial theorem, differential and integral calculus, to say nothing of the work on gravitation—that he must have experimented at high speed. So he missed the lines, and it was reserved for Fraunhofer to discover them 150 years later.[2]

*From *Science Progress*.

[1] *Handbuch der Physiologischen Optik*, 2nd edition, p. 288.

[2] The question as to why Newton missed the Fraunhofer lines has been considered by G. Griffith (*Brit. Ass. Rep.* 1885, p. 941) and by Alexander Johnson (*Trans. Roy. Soc. Canada*, 9, p. 49, 1891). Both authors point out that it was not due to his using a circular aperture instead of a slit, and that the textbooks are wrong on this point. Griffith states that the arrangement was good enough to show the lines, but that possibly part of the work was left to an assistant, and that the latter missed them. Johnson repeated Newton's experiment under similar conditions, and saw plainly ten Fraunhofer lines when the slit was 1/10 in. wide (the greatest width mentioned by Newton). Newton's arrangement of a circular hole 1/10 in. in diameter was found by Johnson to show four lines very distinctly.

When first he describes the spectrum (pp. 22 and 23 of the *Opticks*) there are only five colors mentioned, namely, red, yellow, green, "blew," violet, and again on p. 87 he refers to the spectrum as showing the usual colors on a piece of paper, namely, red, yellow, green, blue, violet; blue this time is spelt in the modern way. This, I think, is the natural description to be expected from a man with normal color vision who sees a bright spectrum spread out as a whole before him for the first time; only when the spectrum is examined strip by strip, the neighboring colors being screened off, are the intermediate colors visible. On p. 92 we find the first mention of indigo; on account of its importance for our purpose I reproduce the entire passage together with its accompanying figure:

"When I had caused the rectilinear line sides AF, GM, of the Spectrum of Colors made by the Prism to be distinctly defined, as in the fifth Experiment of the first book is described,[a] there were found in it all the homogeneal Colors in the same order and situation one among another as in the Spectrum of simple Light, described in the fourth Experiment of that Book. For the Circles of which the Spectrum of compound Light PT is composed, and which in the middle parts of the Spectrum interfere and are intermixt with one another, are not intermixt in their outmost parts where they touch those rectilinear sides AF and GM. And therefore in those rectilinear sides when distinctly defined, there is new Color generated by refraction. I observed also, that if anywhere between the two outmost Circles TMF and PGA a right line, as $\gamma\delta$, was cross to the Spectrum so as at both ends to fall perpendicularly upon its rectilinear sides, there appeared one and the same Color and degree of Color from one end of this line to the other. I delineated therefore in a Paper the perimeter of the Spectrum FAPGMT, and in trying the third Experiment of the first Book, I held the paper so that the spectrum might fall upon this delineated Figure, and agree with it exactly, while an Assistant whose Eyes for distinguishing Colors were more critical than mine, did by right lines $a\beta$, $\gamma\delta$, $\epsilon\zeta$, etc., drawn cross the Spectrum, note the confines of the Colors, that is of the red M$a\beta$F, of the orange $a\gamma\delta\beta$, of the yellow $\gamma\epsilon\zeta\delta$, of the green $\epsilon\eta\zeta\theta$, of the blue $\eta\iota\theta\lambda$, of the indico $\iota\gamma\mu\kappa$, and of the violet γGAμ. And this operation being divers times repeated both in the same and in several Papers, I found that the Observations agreed well enough with one another, and that the rectilinear sides MG and FA were by the said cross lines divided after the manner of a musical Chord. Let GM be produced to X, that MX may be equal to GM, and conceive GX, λX, ιX, ηX, ϵX, γX, aX, MX, be in proportion to one another, as the numbers 1, $\frac{8}{9}$, $\frac{5}{6}$, $\frac{3}{4}$, $\frac{2}{3}$, $\frac{3}{5}$, $\frac{9}{16}$, $\frac{1}{2}$, and so to represent the Chords of the Key, and of a Tone, a third Minor, a fourth, a fifth, a sixth Major, a seventh, and an eighth above that Key. And the intervals Ma, $a\gamma$, $\gamma\epsilon$, $\epsilon\eta$, $\eta\iota$, $\iota\lambda$, and λG, will be the spaces which the several Colors (red, orange, yellow, green, blue, indico, violet) take up."

This account in the *Opticks* was, of course, published in 1704, thirty-eight years after the experiments were made, and represents his final view of the matter. The parallel passage in the *Lectiones Opticæ*, or Optical Lectures, which according to their preface would have been published by Newton about 1671, had it not been for his dislike of controversy, is much fuller, and shows us his views in course of formation.

The passage begins on p. 239[a] and describes how the spectrum was received on a piece of paper, and the boundaries of the different colors as well as their regions of greatest purity marked on the paper, the "ordinary camera" arrangement being used. Then on p. 240 the results of this investigation are given and exhibited.

In a diagram, Fig. 38 of the *Lectiones Opticæ*, Fig. 4 is a somewhat simplified form of this. The diagram shows the whole spectrum divided into sixty parts, and the numbers represent the distances of the points of separation of the colors from the red end. The diagram gives only the five "insigniores colores," as they are referred to. So far orange and indigo have no more claim to importance than sea-green has.

We come now to the reason for their addition to the other five. The purest green lies midway between H and I in the position shown by the dotted line (in this passage in the original all the letters in the text have accidentally been shifted one place to the left, but it is easy to make the necessary correction), but the purest violet, blue, yellow, and red do not occur in the middles of their respective spaces. The purest blue and yellow are nearer the green, and the purest violet and red nearer the ends of the spectrum in the positions shown by the dotted lines. Since the intervals between the purest blue and violet and between the purest red and yellow are about one-third greater than the intervals between the purest green and blue and purest green and yellow, in order to divide the image more elegantly into parts (*quo imago elegantius in partes inter se proportionales distinguatur*) it is advantageous to admit two other colors into the number of the five more important colors, namely, orange between red and yellow and indigo between blue and violet.

Then Newton says he has investigated the limits of the additional colors, and finds that the spaces occupied are connected with the lengths of a vibrating string giving the notes of the octave. This is illustrated by a figure which is practically the same as the Fig. 4 from the *Opticks* (our Fig. 3). Only here the statements are rather more definite; the notes of the octave are referred to as sol, la, fa, ut, re, mi, fa, sol; the spaces $\mu\kappa\iota\lambda$ and $\delta\beta a\gamma$ of Fig. 3 are said to give the two semitones, while the three spaces in the middle occupied by blue, green and yellow, and the end spaces occupied by violet and red, give the five tones. Also the purest part of each color is now said to be in the middle of its space.

In the next section Newton states that owing to its not being possible to observe the limits of the colors sufficiently accurately, they may really differ slightly from the positions given above. He consequently suggests another distribution; put "eleven mean proportionals" between the ends of the spectrum and let $a\beta$, $\gamma\delta$, $\epsilon\zeta$, $\eta\theta$, $\iota\kappa$, and $\lambda\mu$ in Fig. 3 be respectively the second, third, fifth, seventh, ninth, and tenth of these proportionals, and this distribution also satisfies the observations within experimental error. To compare the two distributions he supposes OM = 180; then according to the first one the limits of the colors are at

360, 320, 300, 270, 240, 216, 202½, 180,

and according to the second

360, 321, 303, 270, 240, 214, 202, 180.

Then there are two extremely interesting sentences comparing the merits of the two distributions which may be freely rendered as follows:

"I really prefer the former one, not because it agrees with experiment better, but because it may perhaps suggest analogies between harmonies of sounds and harmonies of colors (such as are not wholly unknown to the painters, but which I have not yet studied sufficiently myself). Such a connection appears more plausible if we note that the affinity between the extreme red and violet, the ends of the spectrum, is of the same kind as between the first and last notes of the octave."

Any one comparing the accounts given in 1669 and 1704 must see that in the earlier year Newton believed that an analogy between the spectrum and the musical scale might contain possibilities of development, but that this belief was not realized. What was the belief due to? It is probable that Kepler's *Harmonices Mundi* had something to do with it. This is the book which is memorable as having announced to the world Kepler's third law, that of the relation between the planetary periods and distances, and which must have been known to Newton about 1669 owing to his explanation of the third law. Miss Clerke, the astronomer, in the biography of Kepler in the *Encyclopædia Britannica*, characterizes the book as an extraordinary production, and states that its main purport was "the exposition of an elaborate system of celestial harmonies depending on the various and varying velocities of the several planets, of which the sentient soul animating the sun was the solitary auditor." Some of the reasoning certainly does appear extraordinary; Kepler not only makes the Deity anthropomorphic but also a mathematician. But I think it is possible to regard the work more sympathetically than this.

Any one wishing to "explain" the universe in Kepler's time had not the analogy of the pendulum, the ideas of force and acceleration, electrons, or the mathematics of wave motion or any of the rest of the modern imagery to his hand. He was restricted to the properties of the geometrical figures and to the laws of harmony, *i. e.* of vibrating strings, which had been discovered by Pythagoras well nigh 2,000 years before. A physical law became necessarily a "harmony" because the first physical laws discovered were those of harmony. Pythagoras, who was the earliest mathematical physicist, and who probably saw the possibility of nature obeying mathematical laws, lived at a time when ideas were not clearly distinguished from things themselves. So the metaphor ran away with his followers, and by a peculiar confusion of thought it became necessary, for example, for the planets actually to give out musical notes as they revolved in their orbits. But there was enough truth seen in Pythagorism to keep it alive, and it had of course, an immense tradition. So it is not to be wondered at that Kepler sought to elaborate and restate it. His attempt undoubtedly led to the discovery of his three laws, and I think that his views, together with the popular way of referring to colors as "harmonizing," must have had some weight with Newton; Newton's own theological writings show he was not averse to mystical speculation. Kepler's ways of thinking appear foreign to physicists nowadays, because his contemporary Galileo inaugurated the experimental method and revolutionized scientific thinking.

[a] *I. e.* the "ordinary camera" method is used.

[a] The reference here is to the Latin edition published in 1729, two years after Newton's death. The lectures were delivered at Cambridge in 1669, and the Latin original was deposited at the time it was read in the archives of the university. The lectures are divided into two parts. The second part, from which the matter here cited is taken, relates to the doctrine of colors, and was recast and improved by Newton in the *Opticks*. The first part is preparatory to the second, and contains much less in common with the *Opticks*. It was published by itself in an English translation in 1728.

Rubber Substitute from German Plants

THE sap of certain *Euphorbiaceæ* growing in Germany has been shown to contain a rubber-like constituent which can be isolated by extracting the dried and powdered plants with ether, carbon tetrachloride, etc., and then adding alcohol to the ethereal extract. Fatty matter is extracted at the same time. Plans of the species *Euphorbia Cyparissias* and *Tithymalus Peplus* are especially mentioned, and it is estimated that if the last named were cultivated on pasture land a yield of 43 kilo. rubber and 120 kilo. fat per hectare could be obtained.—*Pharm. Zeit.*

Locating Submarine Faults

EXAMINATION of seismograph traces with well-marked time scales show that it is possible to locate the corresponding epicentres with sufficient accuracy to indicate the probable line of faulting producing the disturbance. An example is given in the case of the universally recorded earthquake of 1915, May 1. While one adopted epicentre gave a position off Onekotan Island, that from the seismogram from Perth gave a position off Urup Island, indicating a fault line 500 km. long, running in a NE.-SW. direction along the well-known Kurile deep. Greater openness of the time scales is required for finding whether the breakdown is simultaneous or progressive.—*O. Klotz in J. Roy. Astr. Soc. Canada.*

Ancient Trade Weights of the East

MR. W. AIRY has published an interesting paper entitled "On the Ancient Trade Weights of the East." His object has been to present a simplified account of the ancient weights of the East, not including those of China and Japan, and to illustrate their inter-relations. He finds that practically all Eastern weights may be referred to one or other of the following systems: The Egyptian kedet system, based on a kedet of 140 grains; the Egyptian shekel system, based on a shekel of 245 grains; the Phœnician shekel system, based on a shekel of 220 grains; the Babylonian and Assyrian systems, based on a shekel of 254 grains; the Greek Æginetan system, based on a shekel of 54 grains; the Greek Solonian system, based on a drachma of 67.5 grains; and the Roman system, based on a libra of 5,050 grains. —*Nature.*

Removal of Iron from Drinking Water

THE water in the district of Antwerp, in so far as it is not derived from deep wells, has to a large extent the character of moorland water, and, owing to the deposits of iron pyrites in the soil, contains a high proportion of iron as bicarbonate and as ferrous sulphate. Treatment of the water with a mixture of bleaching powder and sodium chloride, and then with Schäffer's aluminium sulphate-charcoal (blood charcoal containing 16.6% of aluminium sulphate), and filtration through a Dunbar filter, removed the iron and gave a sterile water; but it was found that after standing, the water gave a deposit of calcium sulphate, and acquired a bitter taste due to aluminium compounds, while the filter rapidly became choked by the sediment. These drawbacks were obviated by a method in which 250 c.c. of the water is agitated with 400 c.c. of 3% hydrogen peroxide solution, which is added in successive small quantities, this being followed by 100 grms. of finely powdered anhydrous sodium carbonate. The precipitate subsides within 30 mins., and the water can be readily filtered, yielding a filtrate free from iron and practically sterile. The method is suitable for the removal of not too excessive quantities of iron from water, but frequent renewal and disinfection of the filter is advisable.—*Note in Jour. Soc. Chem. Ind. on an article by O. Beck in Z. angew. Chem.*

The Antiquity of the Tamil Speech*

An Investigation into the Beginnings of the Language of Southern India

By Rev. J. Lazarus, B.A., D.D.

THE antiquity of the Tamils and their language is shrouded in myth and mystery. It cannot possibly be traced like that of English, German and other modern languages. The growth of English, for example, has been traced backwards to a point when it was no longer English, but merely Saxon or Gothic altogether, with which we are familiar. Legend has it that Tamil dropped from God Siva's lips like its sister language Sanskrit. If not legend, at least the mysterious cloudiness of the origin of Tamil, is presumptive evidence of its great antiquity.

From time immemorial, Indian grammarians have spoken of but two languages prevailing in the Indian continent, viz., the Northern and the Southern—*Vanda-mori* and *ten-mori*—both being current names for Sanskrit and Tamil. When this distinction was discovered and the epithets introduced, the clear reference was not certainly to the origin of either, but merely to the respective areas in which they were spoken. In fact, evidences point to a date when the so-called Southern tongue was spoken all over India, in the North as well as the South; and the Northern language was struggling hard to find a home in the North and oust its formidable rival southwards beyond the Vindhya Mountains. It is said that at the present time there are not less than a hundred languages and dialects spoken in this country, but they are all derivatives or corrupt dialects of one or the other of these two great languages. Sanskrit is responsible for these in the North and Tamil for these in the South.

Some scholars have fancied that Telugu and the other so-called Dravidian languages are quite independent of Tamil. This is the old song of grown up children turning proud and disowning all relationship to their ancestry. If all the Sanskrit words and derivatives are eliminated from these languages, the residue of words left will be found to be ancient Tamil words, now considered obsolete, or only found in the poetry of bygone days. On the other hand, there are also scholars who pronounce Tamil to be a derivative of Sanskrit and try to trace even the purest Tamil roots to the Northern tongue. For example, a Pandit who has written a book on Tamil Philology derives among others, the word *Tamir* itself from the Sanskrit *Tamas* which signifies heat!

Whence then did Tamil make its appearance in India, if it did not actually descend, like the Mythical Ganga, from the skies? Some dates in the chronology of the Hebrews, the most reliable of ancient records, may be of use in this connection. The deluge to which there are distinct allusions in ancient Indian literature is dated at B. C. 2349. Just one hundred and thirty years thereafter, that is in B. C. 2218, occurred the building of the Tower of Babel, and the confusion of tongues. I look upon this traditional narrative as the explanation of the natural migrations of the branches of one and the same family in search of food for themselves and their flocks and the consequent multiplication of dialects—aptly called the confusion of tongues. The call of Abraham from the now well-known Mesopotamia was in B. C. 1921. Successive migrations extending over a considerable period could not but form distinct highways leading from the Euphrates Delta to India on the East, Palestine on the South, southern Europe on the West and the forests of mid-Europe towards the North.

This period of about 2,000 years seems all too short for the development of the ancient classics and the nations which spoke them. For the science of language has by its great exponent, Max Muller, clearly proved that the ancestors of Sanskrit, Greek and Latin nations once dwelt together, and spoke one and the same language. But considering the marvellous growth and cultivation of a language like English in the short period of about 800 years goes far to prove the adequacy of the time referred to for the mighty changes wrought among peoples and their speeches. Hebrew appears to be the most ancient language spoken among human tribes. Its characters may be traced even in the Devanagari, and once the latter language was like Hebrew written from right to left.

The Tamils evidently preceded the Aryans by at least five centuries. Their Augustan era of literature is now ascertained to have been from B. C. 500 to A. D. 500—quite a literary milennium. The author of Tolkappiyam may have been a contemporary of Socrates in Greece and Buddha in North India. But the fact that this ancient grammarian frequently refers to previous authorities in support of his rules proves that Tamil had already been richly cultivated and possessed a literature, though no traces of it have survived the lapse of time. But the researches of scholars may yet lead to further discoveries of both manuscripts and inscriptions and place in our hands even more ancient classics as well as data. At all events, Tamil literature must have flourished at least prior to B. C. 800. On the other hand it is generally acknowledged that the reducing of the orally chanted Rig Veda Hymns to writing was about B. C. 1500—1800—within which period Aryan immigration into the Indus and Gangetic valleys must have taken place. Also from the rather frequent allusions to Aryan Myths and gods in the Tolkappiyan it is unmistakably clear that Sanskrit influence had already travelled far down to South—The Shen Tamil Nadu—and converted the Tamil people—at least their leaders—to Aryan cults and worship.

But one fact is indisputable. The Tamils were already in India when the Aryans arrived and gradually spread over the peninsula. They were in a state of advanced civilization, with kings and forts, dances and amusements, frequent wars and displays of great valor and courage as well as inland and ocean borne trade. They had transactions with Europeans and Phenœcians as well as Chinese and Japanese. King Solomon who reigned about B. C. 1000, got his peacocks (*tokai*—a pure Tamil word now obsolete but current in Telugu, meaning a tail) from the Tamils. There was thus at this ancient time a free trade and navigation between the Tamils and the Hebrews.

But the literature of the day abounds in references to the aboriginal Nagas, Elnars, Irulas and other savage and primitive tribes but is perfectly silent regarding the language spoken by these tribes. If the post-diluvian migration began about B. C. 2000, and the Tamils were in a prosperous and civilized condition about B. C. 1000, the intervening thousand years, or at least its first half, seeing that the Aryans entered Tamilagam in the second half—was devoted by them to their peaceful pursuits and the refinement of their language. There was no doubt that in those primitive and simple times alliances were formed between the Tamils and the aborigines on the one hand, and the Aryans (chiefly male missionaries) and the Tamil women on the other. What language did these primitive tribes speak? This is an important problem worthy of careful solution of scholars. The descendants of these people, who even now amount to something like 82 per cent. of the total population, speak the Tamil language, though not with the same degree of purity as the Tamils proper. If they had a language of their own previous to the advent of the Tamils and their subsequent mingling with them, are there no traces of its being left in some form on another?

As one probable solution of this problem I suggest that what now passes for Tamil was in those early days really two distinct languages—one with a very limited vocabulary spoken by the Nagas and other tribes, and the other by the Tamils themselves. The presence in Tamil of a considerable number of duplicates or pairs for the same object or action leads me to this hypothesis. There is scarcely a parallel to this feature of Tamil vocabulary in any other language, whether ancient or modern. Just a few examples: *chevi* and *Kathu* (ear), *il* and *vidu* (house), *ti* and *neruppu* (fire), *appan* and *tantai* as well as *amman* and *tai* (father and mother), *mannan* and *Ka* (King), *Kadavul* and *irai* (god), *Kunru* and *Malai* (hill), *Odai* and *Aru* (stream), *nir* and *punal* (water). Now of verbs we have the following pairs: *Kan* and *par* (see), *I* and *ta* (give), *sel* and *po* (go), *tin* and *un* (eat), *kudi* and *paruku* (drink), *ninku* and *villu* (separate), *ni* and *ridu* (let go), *ari* and *teri* (know), etc. Now some of these are always in use in Tamil, while others have either become obsolete or have passed into some other kindred languages like Telugu and Canarese. My conviction is that the latter class of words once formed part of the speech of the Pre-Tamil tribes, and like Anglo-Saxon it got merged into Tamil proper—so that both the races have adopted one common tongue. This is a further proof of the great antiquity of the Tamil race.

The origin of the word *Tamir* should, I think be dwelt on in this connection. When the aborigines heard the sweet words of the Tamil people and saw their more refined manners they naturally called their language sweet (*Tamir*), and themselves *Tamirar*. For to this day all the Tamil depressed classes speak of the Vellalar as the *Tamirar* in contradistinction to themselves—precisely as the ancient Tamils called the newly-arrived Brahmins, *Parppar* (seers) as their chief business was to look into their Suvadies (Olai books) for the times of the stars and planets.

We have thus by a somewhat cumbersome process traced Tamil and its speakers to a date prior to B. C. 2000. Between this date and B. C. 1500, that is during the lifetime of something like 20 generations, while the early Indo-Europeans were developing their speeches and grammars into Sanskrit, and Greek and Latin, the Pre-Aryan Tamils were engaged in a similar effort to reduce their language to writing and constructing their poetic and dramatic styles as well as their grammatical sciences. The period may seem too short for so gigantic a task, but in comparatively briefer periods great Empires rose, flourished, declined and fell. Witness the wonderful change a mere four years' war is effecting in the map of Europe, not to speak of its world wide havoc and ruin. A brief century of British rule is working wonders in this ancient land and transforming its conditions most radically.

Further, I venture to state that there are other equally important facts which carry Tamil into even remoter antiquity. Its grammar, for instance, is mainly characteristic of its people, though its first Aryan authors were naturally tempted to base their rules on Sanskrit grammar. But they knew well that language invariably precedes grammar. Grammar merely collects, classifies and fixes the rules obtaining among the learned who speak a language. Thus unlike Sanskrit, Tamil has no dual, but it has class (*tinai*) which gives rise to five genders. Unlike Sanskrit again, Tamil has no distinction of gender for inanimate objects nor irrational creatures. Tamils never speak or write of a horse or cow as *he* or *she*. The two classes, human and non-human, are quite distinct in the Tamil mind even to this day and afford evidence of an immemorial Pre-Aryan culture. Besides the usual divisions of grammar, treating of letters, words, prosody and rhetoric, Tamil authors expounded what they called *Porul*, subject matter, quite peculiar to the people, and treating of pleasure under the guise of erotics, in harmony with those primitive ages. Even the great author of the Kural could not help following this time-honored philosophy of manners and morals. But in most other respects Tamil grammar bears a striking resemblance to classical grammars, and thus boldly proclaims its hoary antiquity.

There are a number of important pure Tamil words which demonstrate not only the antiquity of the people but their profundity and elevation of thought and conception. To mention but a few, *Kadavul* (god, literally the supreme mind), *Anpu* (love cf. *amo*), *aram* (virtue, cf. *arutes*), *Kalvi* (learning, literally to pick out stones, cf. culture), *Varai* (to write cf. varai-Telugu), *Kural* (short, cf. curt), *Val* (strong, cf. valor), *pa* (song, cf. poem from poies, to make) *er* (plough, cf. aro), *air* (breath, cf. *as*, to breathe). These will suffice for our present purpose. Scores of such primitive words relating Tamil to a language more ancient than even the Classics can be easily picked out of this ancient tongue. It is their long residence near the equator and early mixture with the rude snake-like Nagas that have browned and in some cases even darkened their complexion, though originally they hailed from the same regions as the ancestors of Indo-Aryans. Some of the idioms are identical with those of Hebrew, than which there is scarcely a more ancient extant language. It is far easier for a Tamilian to understand the Hebrew Bible and appreciate and enjoy its figures and terms of expression than a Westerner.

Just a word in conclusion. An examination of the ancient Tamil Script ingeniously arranged by Dr. Burnell in his Indian Palœography will indicate the hieroglyphic origin of its alphabet—at least to a certain extent. Some of these ancient characters seem to have been representations of objects both animate and inanimate. One fact is of a striking nature. The word *eruttu* meant a painting as well as a letter. There is also a resemblance between the Hebrew and Tamil alphabet, though since the time of Asoka's edicts, our characters have been modified to an appreciable extent. At all events the pictorial system carries Tamil further back into antiquity when onomœtopea was utilized for spoken words, and pictorial symbols for written letters.

*From *The Southern Indian Research.*

Radium and Radio-Activity—III

A Consideration of Some of the Physical and Chemical Aspects

By Charles H. Viol

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The nature of the X-rays and the gamma rays was the subject of considerable discussion for many years, although the majority inclined to the opinion that these rays were of the nature of ether pulses. Owing to the fact that the rays could not be defracted or reflected it was not possible to demonstrate satisfactorily their relation to ordinary light. Visible light, as we know, can be defracted by means of a grating made by ruling parallel lines on a suitable plate, using many thousands of lines per inch. It occurred to Laue, a German physicist, that the orderly arrangement of the atoms in a crystal might serve as a grating for the defraction of the X-rays, and at his request Friedrich and Knipping observed the effect of passing a thin beam of parallel X-rays through a crystal of copper sulphate to a photographic plate. The result was a dark central spot on the photogrophic plate corresponding to the direct beam of rays and about this central spot were symmetrically arranged lighter spots corresponding to defracted beams. This marked the beginning of a careful study of the nature of X-rays and the closely related gamma rays. Suffice to say that it seems evident from the work of Moseley, de Broglie, the Braggs, and Rutherford and his students, that all of the elements are characterized by a definite X-ray spectrum. Just as we know, that the different elements have characteristic lines in the visible spectrum, so it has been found that there can be excited by the elements definite vibration of short wave-length which we call X-rays, and a simple relation has been observed between the frequency of these X-ray vibrations of the elements and the elements when they are set in the order of their increasing atomic weight. A general formula has been developed relating the frequency of the characteristic X-rays and certain constants with a variable which is an integer, the particular integer for each element being called the atomic number. By arranging the elements in order of increasing atomic weight numbers may be represented by the integers, beginning with H as unity. This most interesting result for the first time gives us a relation between various elements which does not involve the fractions that are so puzzling in connection with atomic weights, if we could consider the atoms as being built up from a few fundamental units such as electrons and hydrogen nuclei.

Viewed in the light of the Rutherford atom we must assume that the heavier atoms consist of a small nucleus, about which are rotating rings of negative electrons. The mass of the atom depends mainly upon the nucleus, whereas the chemical properties and the visible spectrum depend upon the number and arrangement of the outer electrons. The number of these outer electrons is of the order of one-half the atomic weight, and corresponds to the number of unit positive charges on the nucleus, which in turn corresponds to the characteristic atomic number. The important generalization growing out of this is that the nucleus charge, rather than the atomic weight, is the determining factor governing the chemical and certain physical properties of the elements. The statement of the periodic law must be modified and we may say that the chemical properties of the elements, and those physical properties not dependent on the mass of the atom, are a periodic function of the nucleus charge (atomic number); for, as we shall see, there are elements having practically identical atomic weights (uranium X_1 and uranium X_2) with differing chemical properties, and other elements having measurably different atomic weights (radium G and lead) with identical chemical properties and spectra. If this is the case, then in the uranium atom which has an atomic number of 92, there will be 92 negative electrons moving in orbits about the nucleus. The nucleus is made up of negative electrons and positive electrons. There are good reasons for believing that the alpha and beta rays emitted by radio-active atoms come from the nucleus of the disintegrating atom. It is significant that the helium nucleus rather than the hydrogen nucleus is thrown off, and this would seem to point to a large number of helium nuclei being present in the make-up of the radio-active atom. The helium nucleus we may assume to be made up of four hydrogen nuclei with two negative electrons. It is possible there is a variety of stable configurations similar to the helium nucleus which go together to form the nucleus in the heavier atoms. As far as radio-active evidence shows us, only helium nuclei and negative electrons are emitted in the process of radio-active transmutation; therefore, we may assume, for example, that the nucleus of the uranium atom consists of 59 helium nuclei and 2 hydrogen nuclei and 28 negative electrons, since the atomic weight (238) must be accounted for mainly by the mass of these particles. In the process of transmutation one helium nucleus is lost from the uranium nucleus and the resulting atom is urnanium X_1.

An interesting rule has been given by Soddy to account for the valence changes in the successive radio-elements. Loss of an alpha particle lowers the valence of the succeeding element by 2, whereas the loss of a beta particle increases the valence by 1. A reference to the table of the radio-elements, given before, shows how well the observed results accord with these rules. Uranium 1 with the valence 6 emits an alpha ray and uranium X_1 corresponds in its chemical properties to an atom of valence 4. Uranium X_1 emits a beta particle and uranium X_2 has the valence 5. Uranium X_2 loses a beta ray and uranium II has the valence 6.

This brings up the interesting point of the placing of the radio-elements in the periodic system. The placing of the element in the periodic system signifies that we attribute to the element certain chemical properties. Ordinarily between two closely related elements there are a number of dissimilar elements, so, for example, in passing from sodium to potassium we find magnesium, aluminium, silicon, phosphorus, sulphur, chlorine and argon. In the case of the radio-elements we find practically thirty elements between the atomic weight 206 and 238, so that it is obviously impossible to place each of the elements in a separate place in the periodic table, there being only room for about fifteen elements at most. It was early observed that certain of the radio-elements seemed to be inseparable from each other by the ordinary chemical or physical methods used; for example, a preparation of thorium which should have contained several per cent. of ionium was found to have only the spectrum of thorium, and it was impossible to separate the thorium from the ionium present. Likewise, thorium and radiothorium were found to be inseparable, as were also radium and mesothorium 1. This chemical similarity was at first thought to be comparable to that of the rare earths which have required the most careful work to achieve their separation. Soddy, however, has advanced an hypothesis to account for this chemical similarity which, from the standpoint of importance to chemistry, ranks second only to the generalization of Rutherford and Soddy in regard to the transmutation of the radio-elements. Briefly, this view is that we may have elements of different atomic weight but of identical chemical properties. In the case considered above, uranium I and uranium II differ by about 4 units (1 helium nucleus and 2 electrons) in their atomic weights, but both have the same valence, and it has been found that the two forms of uranium, which were long suspected because of the two alpha rays of different range emitted from uranium, cannot be separated by any known methods. Hence these two elements are grouped together in the one space of the periodic table, and Soddy has suggested for this and similar elements the name isotopes, meaning that they occupy the same position. With this in view and with the rules above referred to, we may readily place all of the radio-elements in the few positions of the periodic table that are available. For example, ionium results from uranium X_2 by the loss of an alpha particle. Ionium is quadrivalent. Radium results from ionium by the loss of an alpha particle. Radium is bivalent, belonging in the group of the alkaline earths. Radium emanation results from radium by the loss of an alpha particle and this gas belongs to that group of noble gases characterized by zero valence. We must bear in mind that the periodic table is best represented by a spiral arrangement of the elements passing from one group up to the next group, so it is not surprising that radium emanation by the loss of an alpha ray produces radium A with a valence of 6, this element finding its position in the next lower group of the periodic table. B, which is quadrivalent, and so on until finally radium F by the loss of an alpha ray produces the element radium G, which there is reason to believe does not undergo any further disintegration. Radium G, by the reasoning above mentioned, should have a valence of 4, and if we subtract 4 for each alpha ray lost, the atomic weight should correspond to about 206. Lead has an atomic weight of 207.15 according to the most accurate determinations, and a maximum valence of 4. For a number of years it was considered that the final product from uranium was lead; however, the difference in the atomic weights was not clearly to be explained. On the basis of this theory of isotopes it becomes very important to determine whether lead occurring in radio-active minerals and presumably due to the atomic disintegration of uranium has the same atomic weight as the lead occurring in ordinary non-radio-active minerals. Of this work we may cite the determinations of Richards and Lembert at Harvard, who found an actual difference in atomic weight between ordinary lead and lead from the uranium minerals, their lowest figure for the radio-active lead being about 206.4. The spectrum and the atomic properties of radium G correspond in every respect to those of ordinary lead, and experiments have shown that these elements can replace each other in the electrodes of concentration cells, showing again the identity of properties of the isotopic elements. In fact, radium B, radium D, and radium G are all chemically identical to ordinary lead.

From the standpoint of the structure of the atom the isotopic elements must be considered as having the same number of electrons in the outer rings, thus conferring similarity of spectra, valence and chemical properties, whereas the difference in the atomic weight is accounted for by the difference in the constitution of the nuclei of the atoms.

The work of Rutherford and Andrade on the characteristic X-ray spectrum of lead and the gamma-ray spectrum of radium B, which is isotopic with lead, is of great interest, since their results point conclusively to the fact that the characteristic X-ray spectrum of lead is the same as the characteristic gamma-ray spectrum of radium B.

The views above mentioned in regard to the nature of the atom and the work on the atomic numbers of the atoms still rest on more or less roughly determined physical data, so that it is possible that more refined measurement will necessitate certain changes in the views, but the work so far goes to corroborate the hypothesis of isotopes and we may safely say that this generalization is one which will not be altered. We have in the group of radio-elements the remarkable condition of the atomic weight not being the important factor in determining the exact chemical nature of the atom, since elements such as uranium X_1 and uranium X_2, which are known to differ by only the mass of an electron, have different chemical natures. On the other hand, as an example, we find radium B, D, G and lead all have different atomic weights with absolute identity of chemical properties. These views are not less striking when compared with the views in regard to the chemical properties of the atoms in the early 90's than are our present views with regard to the transmutation of matter when compared with the views on the same subject several decades ago, and it is the writer's opinion that in these two important generalizations are summed up the most important results of the study of radio-activity from the standpoint of chemistry.

Bone Grafts

As is well known, surgeons insert grafts of living bone to supply defects caused by destructive injuries, but there is a difference of opinion as to the fate of such bone grafts. The opinion most usually held is that they always die, and that they merely help recovery by supplying a framework which is invaded by neighboring living-bone cells. The view that grafts are purely passive in their action is supported by experiments reported by MM. J. Nageotte and L. Sencert (*Comptes. rendus*). So far as all forms of connective tissue are concerned, the authors find that grafts which have been preserved in formalin or alcohol for a month or more serve all the purposes of a living graft. The dead fibre of the graft unites with the living fibre of the host, so that the point of union cannot be detected. The authors excised from the common extensor tendon of a dog's foot a piece 2.5 cm. long, and stitched in its place a corresponding piece of tendon which had been kept in alcohol for a month. When the dog was killed three months later it was found that the dead graft had become so perfectly united with the original tendon that its position could be detected only by the marks of the stitches.—*Nature*.

How the Latent Image on Photographic Plates is Developed

THE opacity of a negative depends not only upon the sensitive emulsion employed and the irradiation to which it has been subjected, but upon the developing fluid and the manner and conditions of the latter's use. A French expert, Dr. Chanoz, has recently made some interesting studies with respect to the variations of opacity in function of the development and has formed a theory as to the method by which the radiations falling upon the sensitive plate and the fluid used to develop it exert their effect. We are indebted to the *Revue Scientifique* (Paris) for the following abstract of Dr. Chanoz' article upon this subject, which appeared originally in the *Annales d'electrobiologie et de radioligie.*

Dr. Chanoz has made a study of the manner in which the various opacities of a given bromo-gelatine sensitive plate will differ under the action of a given developer, ferrous oxalate, and of the exposure, the manner of the latter factor being perfectly known for every point of the plate.

The duration of the development.—At the beginning of this process it is usually found that the blacks of the plate all reveal themselves first at the points which were most exposed corresponding to the high lights in ordinary photography, and then successively in the areas less well exposed and in the shadows. In radiography it is the areas of slight opacity (the soft parts) which first make their appearance, while the opaque areas (the bones) appear later. If the process of development continues the opacities increase, finally attaining at each point a maximum value characteristic of the corresponding exposure. Hence the plate will not show every possible detail of the image unless the duration of the development is sufficiently long. When this minimum duration is reached all the details capable of appearing are visible, and the question may be raised whether it is of advantage to prolong the development more or less. But the important thing in a negative is not merely *the opacity of the ensemble* which is concerned in the facility of examination and in the printing of proofs, but also the *relation* between the opacities of various portions of the plate which gives us the sense of *contrast.* Experiments have proved that this relation does not remain constant throughout the period of development; therefore by varying this or altering the composition of the developer, we can impart one quality or another to the negative image, without its being possible, however, to transform into a perfect negative a plate which has been either under or over exposed.

By modifying the *concentration of the developing bath* we may change the speed of the appearance and the augmentation in opacity of the plate. The experiments made by Messrs. Sheppard and H. Mees prove that the speed of development increases in direct ratio with the degree of concentration. The speed also increases in proportion as the *temperature of the bath* rises.

The mode of operation is by no means a matter of indifference. M. Bouasse observes that "a plate which remains uninterruptedly in the developer for 4 minutes is much thinner than one which during the same length of time is lifted out every 40 seconds and allowed to drip in the air for 24 seconds."

The addition of an alkaline bromide to the developing bath retards the appearance of the image and augments the contrasts in the areas too strongly exposed, which makes it possible to correct the effects of over exposure. The systematic study of degrees of opacity proved to Sheppard and Mees that: 1. The diminution of density due to the alkaline bromide appears only in developments of short duration; 2. That the decrease in density due to the bromide (and observed at the beginning of the development) depends upon the corresponding exposure of the plate.

The minute study of other developers yields similar results. In general, whatever their reducing power, however high their potential of reduction, the various developers finally bring out the same details. As Seyenetz well says: "That which distinguishes them is the relative rapidity with which the details in the shadows appear with respect to the appearance of the details in the light portions and the more or less harmonious relation between the dark and the light half-tones."

In a work relating to the *action upon matter of the various corpuscular and vibrating radiations* Dr. Chanoz has shown that it is now possible to explain the various modifications undergone by irradiated matter by means of the electron theory of matter and of radiations. We need only admit that the primordial and essential fact in the conflict is the violent disturbance of the electrons of the atom (with or without tearing them loose) by means of material shocks in case of corpuscular radiations, and by the electric shock of the corresponding vector where electromagnetic vibrations are concerned. He ascribes the various radiations upon the sensitive plate to the operation of the same mechanism: under the influence of the electric vector of the incident vibration (light, X-rays, etc.) or of the bombardment of the incident corpuscles, (Alpha, Beta rays of radio-active bodies), the electrons are violently disturbed in the complex grain of the gelatine silver bromide. If the degree of commotion is sufficiently great (due either to corpuscular energy or to sufficient vectorial amplitude) corresponding to the limit of *impression,* some electrons are torn from the complex group under consideration. The group therefore is modified by this fact, ionized, and *changed in physico-chemical nature;* the modification thus created constitutes the basis of the latent image.

It is often stated that under the action of the developer only that portion of the silver bromide which has been modified by the radiations employed is of service in reducing the silver; but there are a number of facts which seem to prove that the mechanism of the development is more complex, and that the gelatinic bromide of silver, in particular, even when not irradiated plays one of *the most important* parts in the production of the grains of reduced silver found in the developed plate.

Dr. Chanoz considers three successive phases in the action of the developing bath:

1. The phase of *invasion,* during which the developer attacks the grain of the gelatine bromide of silver, which is the principal element of the sensitive layer;

2. The phase of *reduction* corresponding to the chief chemical reactions concerned in the production of the reduced silver;

3. The phase of *precipitation* corresponding to the appearance and increase in size of the visible grains of silver.

Finally the action of the developing bath, according to Dr. Chanoz consists of the following stages:

1. *The dissolving and ionisation* of those grains of the gelatino-bromide of silver which have not been sufficiently altered by the previous irradiation of the sensitive plate;

2. The *discharge* of the positive silver ions by means of electrons carried by *the anions of the developer* in the developing liquid, and the *formation of metallic silver* in an extremely divided state, which remains temporarily in the condition of *a colloidal solution;*

3. *The granules of the gelatine silver bromide rendered "reactive" by a sufficient degree of irradiation* (i. e. attaining and exceeding a definite limit) act as nuclei of condensation (the "herissons" of Scheffer). *They precipitate at their surface the colloidal silver* formed in the reduction phase at the expense of the unaltered grains (the "nourriciers" of Schexer) and *produce the black grains of reduced silver* found in the plate. These grains *may possibly* attain a considerable volume *independent of the irradiation* of the plate, and conditioned only by the medium.

Prism Binoculars for Detecting Diplopia

IN a subject suffering from affections of the nervous centres, it is found that with direct vision the images on the two retinas are correctly superposed even in the fatigued condition, while in the case of vision through prism binoculars a double image is seen. This phenomenon disappears after a period of rest. The cause cannot be entirely attributed to the increased angle between the rays from the object to the two eyes, but it may be due either (1) to a general lack of accommodation due to the extra fatigue imposed by the strain of accommodating the extra angle for a considerable time, or (2) to a lack of centering of the crystalline lenses with respect to the eyepieces of the binoculars. It is suggested that use may be made of this phenomenon for the detection of defects in the nervous centres, by causing double vision to appear more readily.—*Note in Sci. Absts. on an article by A. Blondel, in Comptes rend.*

Latent Images in Glass

THE whole question of latent images in glass is one well worth threshing out, as it is one of those problems likely to throw useful sidelights on the nature and constitution of glass, and assist in solving other seemingly quite disconnected problems of considerable practical importance. Experiments which I have made during the least years on the introduction of metals into the surface layer of glass have convinced me more and more that we should regard glass as a substance full of ultra microscopic pores. The size, number and shape of these pores near the surface depend on many factors, such as the chemical constitution of the glass, the method of manufacture, the polishing of the surface, fire hardening, etc. When glass is cleaned, rubbed, coated, or treated in any way whatsoever, material is liable to be introduced into the ultra microscopic pores which it may be difficult subsequently to remove by the usual cleaning processes, even when every endeavor is made to do so. I suggest that the material thus left in the pores, forms the basis of the latent image, each filled up surface pore becoming a nucleus or condensation centre for the deposition of moisture or other substance by which the image subsequently becomes visible.—*Julius Rheinberg in The British Journal of Photography.*

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